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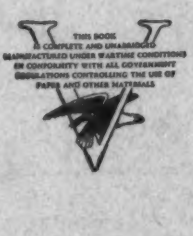
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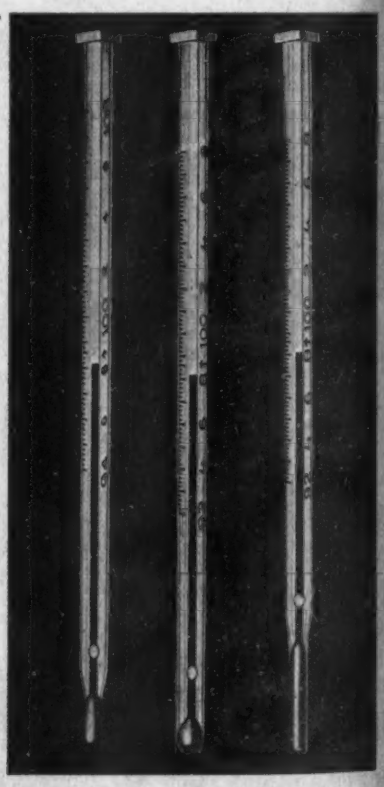

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SPIROMETRIC AND BRONCHOSPIROMETRIC STUDIES IN PNEUMOTHORAX[1]

GEORGE C. LEINER

The effect of pneumothorax treatment on pulmonary function has been studied by few authors. The results of these studies have been summarized by Pinner (1) as follows: "The few data available on long continued studies (Dumarest and Lelong, Pätzold, Herms and Rüttgers) indicate that in the final adjustment, the tidal air is normal or somewhat increased, the respiratory rate is normal and the minute volume is normal or somewhat increased. The period of adjustment for these factors is from one to two months, but the vital capacity reaches its maximum considerably later." Schmidt and Gaubatz (2) stress the value of the minimum breathing capacity. If, by collpase therapy, its value drops to less than twice the minute volume, pulmonary insufficiency is produced.

The function of each lung separately under the influence of pneumothorax was studied in dogs by Moore and Cochran (3) and in rabbits by Torning (4). Björkman (5) and Jacobaeus (6) were the first to do bronchospirometry on patients before and shortly after the induction of pneumothorax. Adams (7) is of the opinion that pulmonary function tests, bronchospirometry included, have no practical value and are of interest only for respiratory physiology.

Leiner, Pinner and Zavod (8) discussed the bronchospirometric findings in one patient before and after pneumothorax induction.

METHOD

The pulmonary function of every patient was studied twice: before the induction of pneumothorax and after pneumothorax had been established. Spirometry was done to study the total pulmonary function; and bronchospirometry, to determine the function of each lung separately.

Spirometry was nearly always done first, mainly for two reasons: (*1*) To get general information of the pulmonary function; this might make a bronchospirometric examination unnecessary either because the pulmonary function is so poor as to preclude any form of collapse therapy, or because it is normal or nearly normal. (*2*) To get the patient acquainted with the method so that he is less excited at bronchospirometry and understands better what he has to do and how he has to coöperate.

The spirometric method used was closely similar to that described by Cournand, Richards and Darling (9).

Spirometry was always done under basal conditions. The patient was examined in the morning, without breakfast, resting on a stretcher. The data which were determined were:

1: Oxygen intake per minute.
2: Basal metabolic rate.

[1] From the Division of Pulmonary Diseases, Montefiore Hospital for Chronic Diseases, New York, New York.

3: Minute volume of respiration, that is, the amount of air ventilated in one minute.
4: Tidal air.
5: Respiratory rate.
6: Ventilation equivalent for oxygen, that is, the amount of air in liters which a person ventilates in order to take up 100 cc. of oxygen; the normal value under basal conditions is between 2 and 3 liters.

The data 1 to 6 were obtained under two conditions: first, when the patient was breathing air and, then, when he was breathing pure oxygen. Patients with significant degrees of anoxaemia absorb more oxygen when breathing pure oxygen, than when breathing air: an oxygen deficit exists. In most of our patients who underwent collapse therapy the two sets of data were practically the same and we will therefore present only the figures determined under oxygen breathing.

We determined, furthermore:

7: Vital capacity.
8: Reserve air.
9: Complementary air.
10: Maximum breathing capacity, that is, the maximum amount of air a person can ventilate when asked to breathe as deeply and as fast as possible.
11: The factor $\frac{\text{Maximum breathing capacity}}{\text{Minute volume}}$, which is a reliable index of the ventilatory reserve.

Most patients were also submitted to an exercise test: They had to walk up and down a step twenty-five times in one minute, the height of the step was 30 cm. Immediately after the completion of this exercise, ventilation was recorded again with the patient resting on a stretcher. The period of the postexercise test was six minutes. The results of the exercise test and the effect of collapse therapy upon it will be discussed in a later publication.

Bronchospirometry was performed on another day. It was done with the soft-rubber catheter described by Zavod (10), through which the patient breathed pure oxygen. Basal conditions do not exist during bronchospirometry and the figures are—with the exception of vital capacity—not directly comparable with those obtained by spirometry (Pinner, Leiner and Zavod (11)). However, results of repeated bronchospirometric examinations in the same patent can be compared and this will be done in this paper.

By bronchospirometry we determined for each lung separately: (*1*) oxygen intake per minute; (*2*) minute volume of respiration; (*3*) tidal air; (*4*) respiratory rate; (*5*) ventilation equivalent for oxygen; (*6*) vital capacity; (*7*) reserve air; (*8*) complementary air. In many patients attempts were made to record maximum breathing capacity; but the results were unreliable and not reproducible and we had to conclude that, under conditions of the experiment, it is, as a rule, impossible for the patients to maintain the necessary sustained ventilatory effort. Maximum breathing capacity for single lungs will, therefore, not be reported.

RESULTS

Pulmonary function was studied in 18 patients (13 males and 5 females) before and after induction of pneumothorax. The first examination was performed a few days before collapse therapy was started, the second examination one to eleven months after pneumothorax induction.

Spirometry: The changes in the total pulmonary function, brought about by pneumothorax, are determined by spirometric studies. Space does not permit

TABLE 1

Spirometry before and after induction of pneumothorax

	OXYGEN INTAKE IN CC.	BMR IN PER CENT	MINUTE VOLUME IN CC.	TIDAL AIR IN CC.	RESPIRATIONS PER MINUTE	VENTILATION EQUIVALENT IN LITERS	VITAL CAPACITY IN CC.	RESERVE AIR IN CC.	COMPLEMENTARY AIR IN CC.	MAXIMUM BREATHING CAPACITY IN LITERS	MAX. BR. CAP. / MINUTE VOL.
	Number of patients										
	18	18	18	18	18	18	18	17	17	18	18
Mean											
before..	234	+3	6,510	491	14	2.4	2,910	598	1,893	62.4	9.8
after...	223	−4	6,700	513	14	2.6	2,070	317	1,284	51.3	7.7
Highest											
before..	315	+22	8,510	906	28	3.4	4,450	1,036	3,410	109.8	16.4
after...	310	+21	8,860	986	23	3.8	3,640	621	2,498	89.2	12.2
Lowest											
before..	179	−17	3,970	271	8	1.7	1,530	0	1,106	37.3	5.3
after...	149	−26	4,780	357	7	1.8	1,330	83	612	27.4	3.9

TABLE 2

Changes in total lung functions caused by pneumothorax

	OXYGEN INTAKE	BMR	MINUTE VOLUME	TIDAL AIR	RESPIRATION PER MINUTE	VENTILATION EQUIVALENT	VITAL CAPACITY	RESERVE AIR	COMPLEMENTARY AIR	MAX. BREATHING CAPACITY	MAX. BR. CAP. / MIN. VOL.
Increase.....	1	1	7	7	4	8	0	1	0	1	3
Unchanged...	12	12	6	3	10	8	1	0	1	7	2
Decrease.....	5	5	5	8	4	2	17	16	16	10	13

the reproducton of the figures for each case; their discussion would lead to unnecessary details. The pertinent results are presented in summarized form.

Table 1 shows the mean, maximum and minimum values before and during the presence of pneumothorax and table 2 indicates the frequency with which the changes reported occurred. Changes of more than 10 per cent were considered to be of significance, differences of less than 10 per cent are classed as "unchanged." In the majority of patients, the differences in oxygen intake between pre- and postcollapse condition are not significant. In the remainder, the oxygen intake

decreases slightly, corresponding to a slight decrease of the basal metabolic rate. This decrease may be caused by abatement of toxaemia, drop in average temperature and loss of weight, but these possible causes for a decreased basal metabolic rate are not regularly demonstrable. A drop in basal metabolism in children under pneumothorax treatment has been observed by Topper and Rubin (12). A detailed report on the basal metabolic rate in pulmonary tuberculosis is being prepared (13).

The means of minute volume of respiration, tidal air and respiratory rate are not affected by pneumothorax treatment. Changes would occur in patients in whom pneumothorax causes respiratory insufficiency, a condition that was not observed in any of our pneumothorax patients.

With the mean oxygen intake slightly diminished and the minute volume unchanged, the mean ventilation equivalent increases slightly, indicating that, in the average, a lung collapsed by pneumothorax functions somewhat less efficiently. But in 8 out of 18 cases no significant increase of the ventilation equivalent occurred and in 2 a decrease was noted. The latter phenomenon must be explained by the collapse of portions of lung tissue with poor circulation.

The vital capacity dropped considerably in all but one patient; the average decrease was nearly 30 per cent.

The mean reserve air diminished in all but one patient, the average reduction being almost 50 per cent. The same is true for the complementary air which showed a mean reduction of about 30 per cent.

The tidal air was as frequently increased as it was decreased, the mean showing no difference. Since, as stated, the vital capacity is considerably reduced by pneumothorax, the volume of the tidal air in percentage of the vital capacity increases during pulmonary collapse from 17 to 25 per cent. This, in itself, indicates a reduction of ventilatory reserve. Reserve air and complementary air as well show a slight decrease relative to vital capacity (table 8).

Maximum breathing capacity and $\frac{\text{Maximum breathing capacity}}{\text{Minute volume}}$ show a definite decrease in their mean values, which is however less extensive than the decrease of the vital capacity. Occasionally an increase in maximum breathing capacity and $\frac{\text{Maximum breathing capacity}}{\text{Minute volume}}$ can occur (tables 2 and 3).

Bronchospirometry: Of our 18 patients, 12 received pneumothorax on the right side and 6 on the left side. The means, maxima and minima for each lung are presented in tables 4 and 5.

With a right-sided pneumothorax the means for the collapsed side were as follows: the oxygen intake decreased by about 30 per cent; minute volume and tidal air, by about 25 per cent. Consequently, the ventilation equivalent showed a slight increase. The vital capacity dropped by more than 40 per cent, the reserve air by about 60 per cent, the complementary air by more than 60 per cent. The respiratory rate remained practically unchanged. The figures for the subdivisions of the vital capacity, with marked reductions in reserve and complementary air, emphasize the diminished ventilatory reserve of the collapsed lung.

TABLE 3

Maximum breathing capacity and $\frac{\text{Maximum breathing capacity}}{\text{Minute volume}}$ *before and after induction of pneumothorax*

CASE	MAXIMUM BREATHING CAPACITY IN LITERS			MAXIMUM BREATHING CAPACITY / MINUTE VOLUME		
	Before	After	Change in per cent	Before	After	Change in per cent
49	57.5	53.3	−7	7.1	8.4	+19
69	37.3	50.4	+35	9.4	10.2	+9
129	60.9	38.8	−36	8.9	4.5	−49
149	65.9	65.3	−1	7.7	9.0	+17
155	83.4	45.0	−46	12.3	7.9	−36
170	72.0	48.3	−33	10.3	7.2	−30
176	56.5	27.4	−51	7.6	3.9	−49
221	38.1	39.5	+4	5.3	6.2	+17
225	47.6	38.4	−19	8.2	8.0	−2
264	54.9	56.5	+3	10.2	8.2	−20
181	40.0	27.4	−32	6.6	4.8	−27
219	53.2	50.5	−5	7.0	5.9	−16
239	62.0	54.4	−12	8.4	7.0	−17
111	74.0	59.8	−19	15.0	12.2	−19
294	72.4	65.3	−10	12.0	9.0	−25
326	53.9	32.9	−39	12.5	6.4	−49
291	84.0	80.7	−4	11.8	10.4	−12
292	109.8	89.2	−19	16.4	10.1	−38

TABLE 4

Bronchospirometry before and after induction of right pneumothorax

	RIGHT LUNG							RESPIRATIONS PER MIN.	LEFT LUNG						
	Oxygen intake in cc.	Minute volume in cc.	Tidal air in cc.	Ventilation equivalent in liters	Vital capacity in cc.	Reserve air in cc.	Complementary air in cc.		Oxygen intake in cc.	Minute volume in cc.	Tidal air cc.	Ventilation equivalent in liters	Vital capacity in cc.	Reserve air in cc.	Complementary air in cc.
	Number of patients														
	11	12	12	11	10	9	9	12	11	12	12	11	10	9	9
Mean															
before..	190	5,500	274	2.9	1,410	463	754	22	139	5,460	275	4.7	1,230	407	579
after...	123	4,200	224	3.1	800	189	362	21	182	6,190	307	3.3	1,110	361	501
Highest															
before..	300	7,970	569	5.5	2,180	725	1,247	32	212	8,240	577	16.4	1,700	663	977
after..	213	6,150	484	5.8	1,390	497	675	34	313	8,780	474	5.2	1,990	663	880
Lowest															
before..	88	3,840	154	1.2	580	186	369	14	26	4,120	134	2.0	540	104	40
after...	57	1,920	57	1.9	330	83	62	11	86	4,890	229	1.5	390	62	141

On the contralateral side there was a compensatory increase of the oxygen intake, accompanied by a less pronounced rise of minute volume and tidal air. The ventilation equivalent, therefore, decreased, an indication of one compensatory mechanism in the contralateral lung which is not dependent on increased ventilation but on increased pulmonary circulation.

Vital capacity, reserve air and complementary air showed slight decreases also in the noncollapsed lung. This is apparently the effect of mediastinal shift towards the contralateral side and of transmitted increase in intrapleural pressure. However, since the ventilation equilvalent of the contralateral lung decreases, one must assume that the capillary bed in this lung is widened; this

TABLE 5

Bronchospirometry before and after induction of left pneumothorax

	RIGHT LUNG							RESPIRATIONS PER MIN.	LEFT LUNG						
	Oxygen intake in cc.	Minute volume in cc.	Tidal air in cc.	Ventilation equivalent in liters	Vital capacity in cc.	Reserve air in cc.	Complementary air in cc.		Oxygen intake in cc.	Minute volume in cc.	Tidal air in cc.	Ventilation equivalent in liters	Vital capacity in cc.	Reserve air in cc.	Complementary air in cc.
	Number of patients														
	6	6	6	6	5	5	5	6	6	6	6	6	5	5	5
Mean															
before..	153	4,820	235	3.3	1,340	418	697	20	151	4,640	274	2.9	1,480	526	651
after....	196	5,950	327	2.9	1,300	389	641	19	96	4,140	237	4.6	820	153	407
Highest															
before..	400	7,370	309	4.5	2,150	828	1,045	27	230	6,530	620	4.3	1,660	621	961
after....	406	11,000	610	4.0	1,910	642	1,091	25	261	6,250	521	8.3	1,510	414	575
Lowest															
before..	54	1,920	162	1.6	430	104	113	9	95	3,160	117	1.6	1,240	331	419
after....	63	2,720	219	2.3	310	41	42	12	37	1,810	101	2.1	480	0	260

fact in itself may cause a certain decrease in the vital capacity and its subdivisions.

With a left-sided pneumothorax the effects on the individual pulmonary functions were similar. The direction in which the means changed was the same, the degree of the changes being slightly but probably not significantly different from that of the cases with right-sided pneumothorax.

Table 6 shows the means for all collapsed lungs and all contralateral lungs before and after induction of pneumothorax, irrespective of the side of collapse. A discussion of this table appears unnecessary as there are no principal differences between it and tables 4 and 5. Only one thing should be pointed out: the ventilation equivalent before collapse is, in practically every case, higher in the diseased lung than in the contralateral lung; however, the means would indicate the opposite. This is caused by 2 single cases with high ventilation equivalents in the contralateral lung: one 4.5 for the (right) contralateral lung and one 16.4 for

the (left) contralateral lung. In these cases with unusually high ventilation equivalents for the contralateral lung, disease and previous treatment accounted for the atypical behavior.

Changes of the functions of one lung are not conclusive without considering the changes in the other lung. For instance, a decrease in oxygen intake of one lung is due to a diminished pulmonary (or vascular) function if the other lung shows a compensatory increase at the same time. If it is, however, accompanied by a similar decrease in the other lung, it may be due to a diminished oxygen requirement. (The patient might be less excited, less toxaemic or he may have lost weight, and so on.) In order to show the changes, caused by collapse, more clearly, they were calculated as changes in percentage of the total pulmonary function, the total pulmonary function being determined by adding the functions of both sides.

TABLE 6

Bronchospirometry before and after induction of pneumothorax

	PNEUMOTHORAX LUNG							RESPIRATIONS PER MIN.	CONTRALATERAL LUNG						
	Oxygen intake in cc.	Minute volume in cc.	Tidal air in cc.	Ventilation equivalent in liters	Vital capacity in cc.	Reserve air in cc.	Complementary air in cc.		Oxygen intake in cc.	Minute volume in cc.	Tidal air in cc.	Ventilation equivalent in liters	Vital capacity in cc.	Reserve air in cc.	Complementary air in cc.
	Number of patients														
	17	18	18	17	15	14	14	18	17	18	18	17	15	14	14
Mean															
before...	176	5,220	274	2.9	1,430	485	717	21	144	5,250	261	4.2	1,270	411	611
after.....	114	4,180	228	3.7	800	176	378	20	187	6,110	314	3.1	1,170	371	551

The following formula was used: Change in per cent of any function of right side:

$$\left[\left(\frac{R_a}{R_a + L_a} - \frac{R_b}{R_b + L_b}\right) : \frac{R_b}{R_b + L_b}\right] \times 100$$

Or:

$$\left(\frac{R_a(R_b + L_b)}{R_b(R_a + L_a)} - 1\right) \times 100$$

R_b and R_a are the respective figures for the right lung, before and after institution of collapse therapy, L_b and L_a the respective figures for the left lung. This formula was used for all data with the exception of the ventilation equivalent. The change in ventilation equivalent was calculated by the formula: Change in per cent $= \frac{VE_a - VE_b}{VE_b} \times 100$, where VE_b and VE_a are the ventilation equivalents for the respective side before and after institution of collapse therapy.

The results of these calculations are summarized in table 7. The relative

oxygen consumption of the collapsed lung decreased in most cases; on the contralateral side there was usually a compensatory increase. Minute volume and tidal air (in this form of calculation these two items always show identical changes, as tidal air is $\frac{\text{Minute volume}}{\text{Respiratory rate}}$, the respiratory rate being the same on both sides) decreased or remained unchanged on the collapsed side; they increased or remained unchanged on the contralateral side. The ventilation equivalent increased more often than not on the collapsed side and decreased more often than not on the contralateral side. Vital capacity, reserve air and complementary

TABLE 7

Relative changes in the functions of each lung by pneumothorax

(Explanation in the text)

	PNEUMOTHORAX LUNG						CONTRALATERAL LUNG					
	Oxygen intake	Minute volume, Tidal air	Ventilation equivalent	Vital capacity	Reserve air	Complementary air	Oxygen intake	Minute volume, Tidal air	Ventilation equivalent	Vital capacity	Reserve air	Complementary air
Increase	1	0	10	1	2	1	14	10	6	12	11	13
Unchanged	3	10	3	1	0	0	2	8	2	2	1	0
Decrease	13	8	4	13	12	13	1	0	9	1	2	1

TABLE 8

Means of subdivisions of vital capacity in per cent of vital capacity, before and after induction of pneumothorax

	SPIROMETRY			PNEUMOTHORAX LUNG			CONTRALATERAL LUNG		
	Tidal air	Reserve air	Complementary air	Tidal air	Reserve air	Complementary air	Tidal air	Reserve air	Complementary air
Mean									
before	18	19	63	20	32	48	23	30	47
after	26	14	60	32	21	47	30	28	42

air behaved in the same way as the oxygen intake: there was usually a relative decrease on the collapsed side and a relative (not absolute, in contradistinction to the oxygen intake) increase on the other side.

In 14 cases we calculated for either side tidal air, reserve air, complementary air in per cent of the vital capacity of the respective side, before and after induction of the pneumothorax. The means of these values are shown in table 8. In the collapsed lung the tidal air increased from 20 to 32 per cent of its vital capacity; the percentage of the reserve air decreased from 32 to 21, and the complementary air remained practically unchanged. This means that, with the tidal air presenting a larger part of the vital capacity, the ventilatory reserve of the collapsed side is diminished. From the decrease in reserve air we can

conclude that the lung is shifted into a more expiratory position (lower mid-capacity).

On the contralateral side the means before and after induction of a pneumothorax were: for tidal air 23 and 30 per cent; for reserve air 30 and 28 per cent; for complementary air 47 and 42 per cent. The changes in tidal air and reserve air were in the same direction but less pronounced on the contralateral side than on the pneumothorax side, indicating again a slight contralateral effect of collapse by pneumothorax.

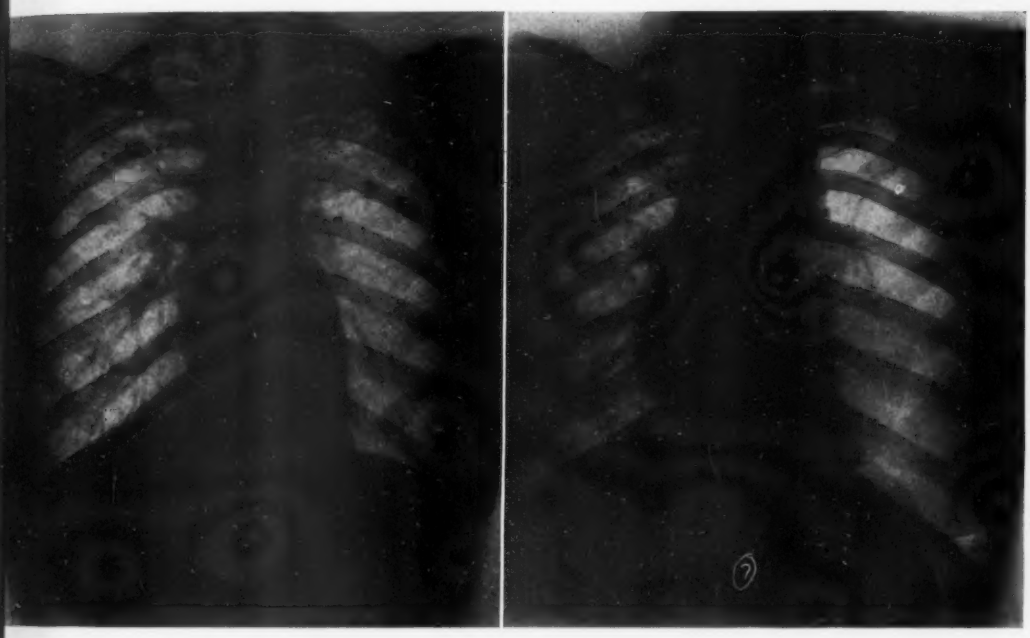


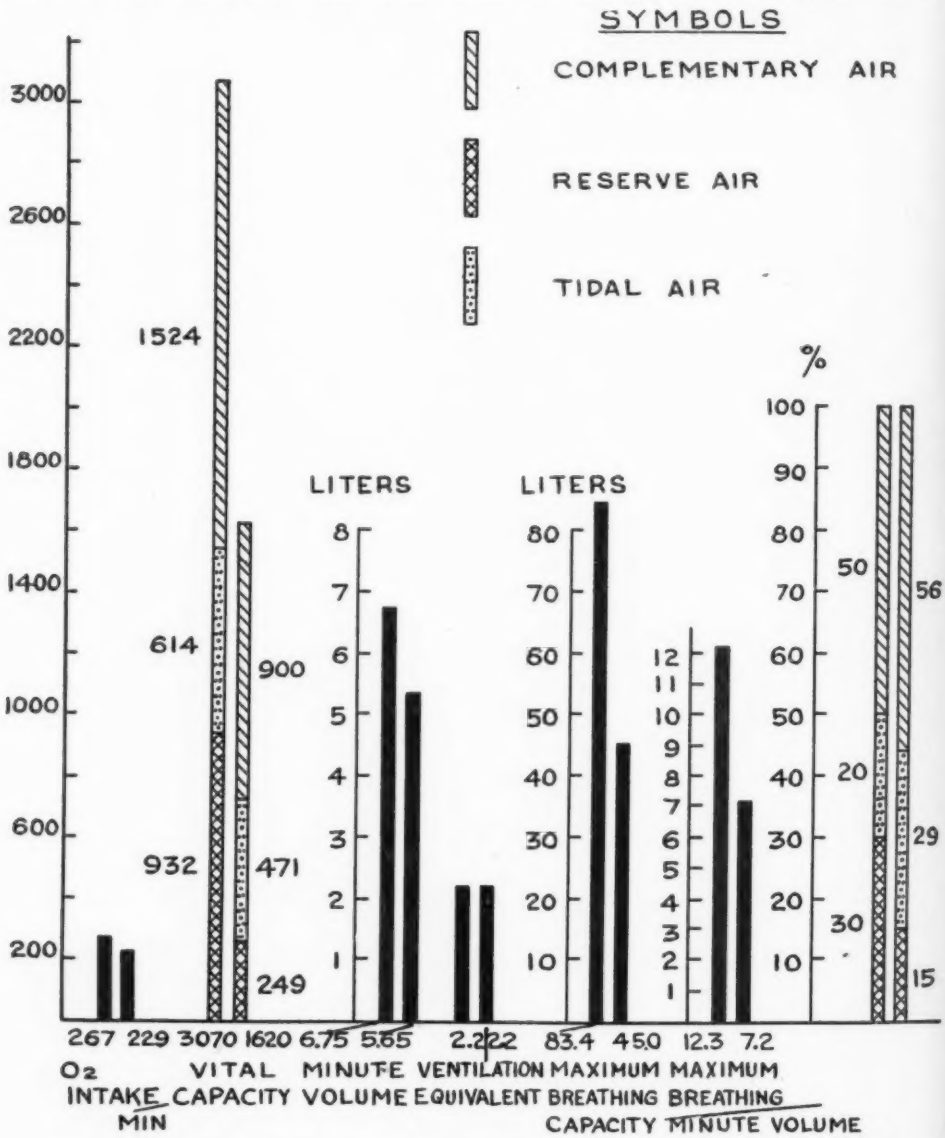
FIG. 1. (Left.) Chest X-ray film of patient A. G., May 6, 1940.

FIG. 2. (Right.) Chest X-ray film of same patient, October 22, 1940—five months after induction of pneumothorax on the left.

The functional effects of unilateral pneumothorax will be illustrated by a representative case.

No. 155, *A. G.*, was a thirty-year-old female, who complained of productive cough of ten years duration. X-ray examination on May 6, 1940 (figure 1) revealed mixed infiltrations bilaterally from apex to third anterior rib, more on left than on right; there was probably a small cavity on the left side. Spirometric studies were done on May 13, 1940; bronchospirometric studies on May 17, 1940. On May 20, 1940, a pneumothorax was induced on the left side. The tests were repeated on October 9, 1940 and on October 11, 1940, respectively. An X-ray examination on October 22, 1940 (figure 2) showed about 60 per cent collapse of the left lung with one large adhesion at the level of the second anterior rib and considerable shift of the mediastinum to the right. The general condition of the patient was good.

Graph 1 shows the data as found by spirometry. The first half of each double column presents the values before collapse, the second half, after induction of collapse. We see

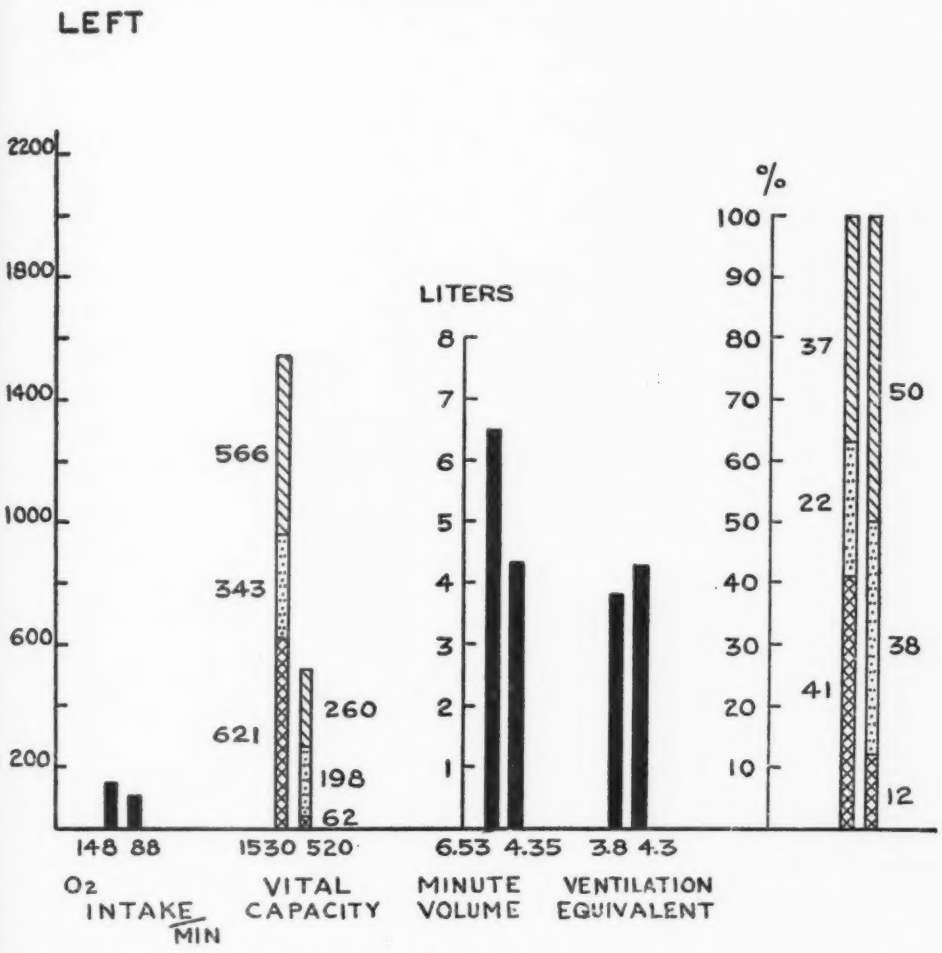


GRAPH 1. Spirometric findings in patient A. G.; the first half of each double column as of May 13, 1940 (before pneumothorax), and the second half as of October 9, 1940 (after induction of pneumothorax).

Note: In graphs 1, 2 and 3, the last two columns show the percentage distribution of the subdivisions of vital capacity before and after induction of pneumothorax.

a moderate decrease of the oxygen intake, associated with a reduction of the basal metabolic rate from +22 per cent to −4 per cent. During that time the general condition of the patient improved, her toxaemia subsided, as shown by a return of the high leuco-

cyte count to normal and by a decrease of the sedimentation rate. The minute volume is smaller during pneumothorax treatment, and, as the respiratory rate increases from 11 to 12, the tidal air is diminished too. The ventilation equivalent remains unchanged. The vital capacity drops considerably, with all its subdivisions (reserve air, tidal air, complementary air) partaking in this drop. However, the subdividions of the vital capacity



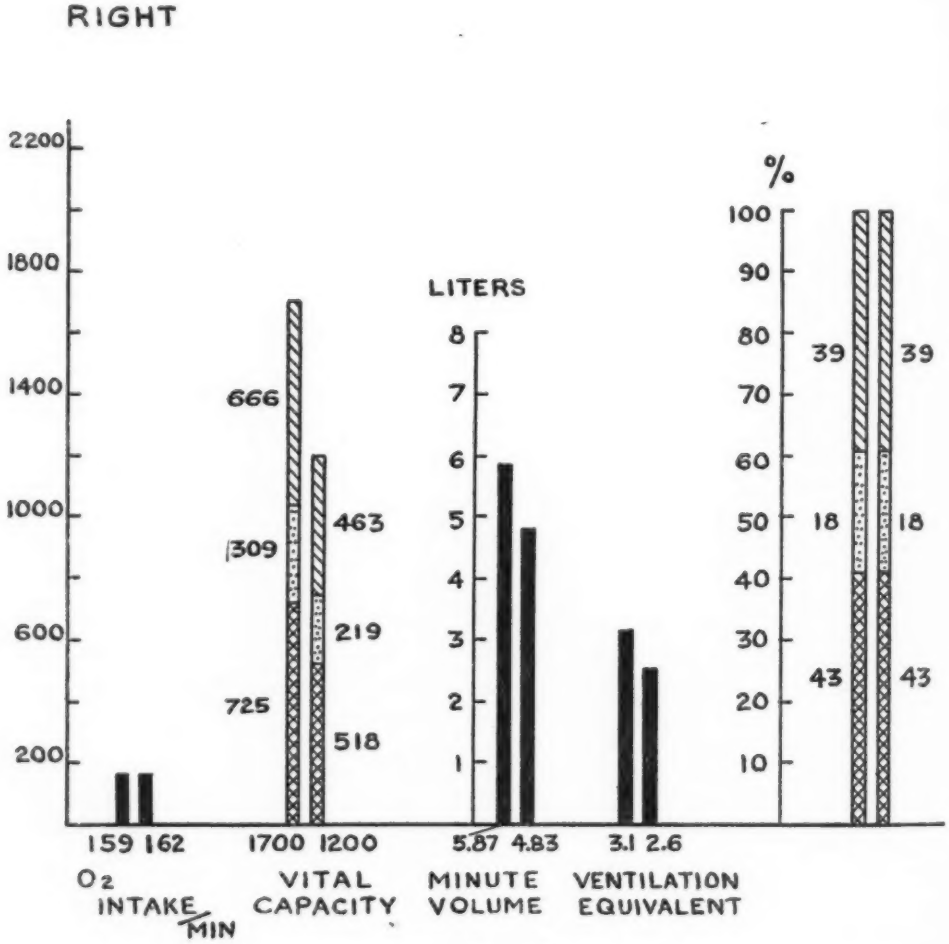
GRAPH 2

GRAPHS 2 & 3. Bronchospirometric findings in patient A. G.; the first half of each double column as of May 17, 1940, and the second half as of October 11, 1940.

do not show an equal decrease, as seen from the last pair of columns of graph 1, which shows the subdivisions of the vital capacity in percentage of the vital capacity. The tidal air, which before the collapse amounts to 20 per cent of the vital capacity, amounts to 29 per cent after the collapse, in spite of its absolute decrease from 614 to 471 cc. The percentage of the reserve air is decreased to one-half, the complementary air increases its percentage slightly. Maximum breathing capacity and the factor

$\frac{\text{Maximum breathing capacity}}{\text{Minute volume}}$, which were normal before collapse, show a considerable decrease.

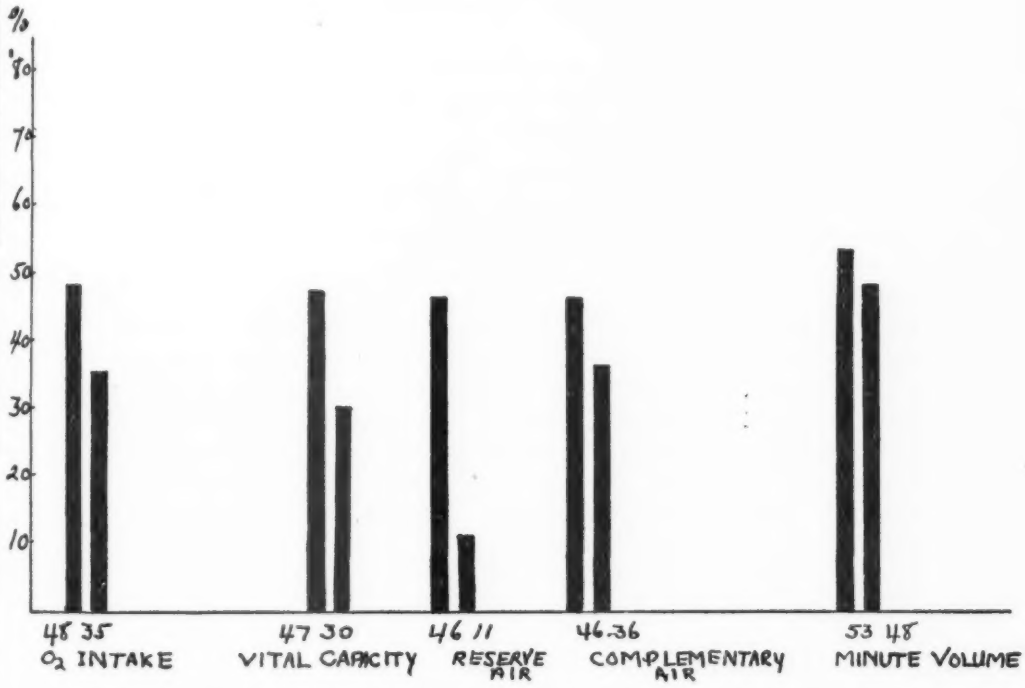
What change does each lung show separately? How much decrease or increase of the various values is due to the right or to the left lung? Graphs 2 and 3 answer these questions.



GRAPH 3

The left side, on which at the time of the second examination a pneumothorax with a 60 per cent collapse of the lung was present, showed a marked diminution of the oxygen intake; on the right side the oxygen intake remained the same. The large reduction of vital capacity and particularly of reserve air in the collapsed lung should be pointed out, as well as the fact that, in terms of percentages of vital capacity, the tidal air has much increased, though its absolute value has decreased. The ventilation equivalent moved in opposite directions in the lungs.

It can be seen that the vital capacity and its subdivisions dropped on both sides, by far more on the collapsed side. The diminution of these values on the right side, in which no collapse therapy has been instituted, was apparently due to the shift of the mediastinum. The relative changes of the subdivisions of the vital capacity, which we saw on spirometry, are due, in this case, to changes on the collapsed side only. The tidal air, which before the pneumothorax amounted to 22 per cent of the vital capacity, increased to 38 per cent; the reserve air dropped from 41 to 12 per cent; the complementary air increased from 37 to 50 per cent of the vital capacity. The contralateral side showed no changes in the mutual relations of reserve air, tidal air, complementary air, although all of them decreased in their absolute values.



GRAPH 4. Bronchospirometric data for left lung in per cent of total pulmonary function, before and after induction of pneumothorax.

As pointed out above, absolute figures are not important in bronchospirometry, since the patient is not under basal condition and since the respiratory mechanism is modified in a similar way as in stenosis breathing. The percentage distribution between right and left side is important.

Graph 4 shows the percentage distribution between the two sides. Only the values for the left lung are shown, since those for the right would simply be a mirror picture of the former. Before collapse, oxygen intake, vital capacity with its subdivisions amounted to a little less than 50 per cent of their respective totals, as is normal; following collapse, they are reduced to 30 to 36 per cent; only the reserve air shows a much greater diminution. These figures compare well with those found in spirometry. The metabolism has decreased and the noncollapsed side, therefore, has not a larger amount of work to do

than before the collapse, in spite of the decrease of work done by the collapsed lung. The compensation for the left lung was achieved, in part, by a decrease of the ventilation equivalent for the right lung.

DISCUSSION

Unilateral uncomplicated pneumothorax does not interfere with the ventilatory function under basal condition. This is again shown in the 18 cases here presented. While the vital capacity, the reserve air and, to a lesser degree, the complementary are reduced, tidal air and minute volume are not seriously affected. However, the ventilatory reserve, as shown by the maximum breathing capacity and by its relation to minute volume, is considerably reduced. This occurred in 13 out of 18 patients (table 2).

The main aim of these observations is to show, by bronchospirometric studies, how the single lungs are affected by unilateral pneumothorax and particularly how the contralateral lung compensates for the functional loss of the collapsed lung.

Observations on the 18 pneumothorax lungs are not sufficient to draw general and final conclusions, but they show some definite trends, the regularity of which will have to be confirmed by further studies.

From a practical point of view it is important that in the average, and with exceptions, the oxygen intake of the collapsed lung shows a considerable decrease. This is compensated for by a somewhat smaller increase of oxygen intake in the contralateral lung and by a decrease in the oxygen requirement of the patient. The mean of the percentage increase in the oxygen intake of the contralateral lung (30 per cent) was considerably greater than the percentage increase of its minute volume (16 per cent) (table 6). In other words, the decrease of oxygen intake in the collapsed lung (35 percent) was compensated for by some increase in the ventilatory work of the contralateral lung. The respiratory function of the contralateral lung became more efficient owing to an improved relation between ventilation and circulation, as indicated by a drop in the ventilation equivalent from 4.2 to 3.1. This is a numerical confirmation of the clinically and experimentally established fact that the decreased function of the collapsed lung is not made up for by an equivalent increase in the ventilatory work of the contralateral lung. In individual cases, the minute volume of the contralateral lung remained unchanged in 3 cases, showed a decrease in 3 cases and an increase in 12 cases.

According to expectation, all pulmonary volumina are decreased in the collapsed lung and the contralateral lung tends to compensate for this by increasing its tidal air and minute volume. But the other pulmonary volumina, that is, vital capacity, reserve and complementary air, are decreased in the contralateral lung as well as in the collapsed lung, although to a lesser degree.

The reader should remember that the studies presented refer to patients *during* pneumothorax treatment, and, as a matter of fact, during the first year of pneumothorax treatment. More severe functional damage of the collapsed lung occurs, at least in some cases, before or during reëxpansion. In a previous

publication (11) it was pointed out that *some* lungs that had been collapsed by pneumothorax had practically no functional capacity left after absorption of the intrapleural air.

SUMMARY

1. Pulmonary function was studied by spirometry and by bronchospirometry in 18 patients before and after induction of pneumothorax.

2. Total pulmonary functions showed in their mean values the following behavior: There was a slight decrease of the oxygen intake, corresponding to a slight decrease of the basal metabolic rate. Minute volume of respiration, tidal air, respiratory rate remained unchanged. The ventilation equivalent increased slightly. Vital capacity, reserve air and complementary air dropped considerably. There was a definite decrease in maximum breathing capacity and $\frac{\text{Maximum breathing capacity}}{\text{Minute volume}}$.

3. Bronchospirometry revealed the following changes in the collapsed lung: a considerable decrease of the oxygen intake, a somewhat lesser diminution of minute volume and tidal air and an increase in the ventilation equivalent, showing a less efficient use of the ventilated air. Vital capacity, reserve air and complementary air dropped considerably.

4. The contralateral lung was affected as follows: There was a compensatory increase of the oxygen intake, a less pronounced rise of minute volume and tidal air, and a slight decrease of the ventilation equivalent, showing a better use of the ventilated air. Vital capacity, reserve air and complementary air dropped slightly, probably due to shift of the mediastinum and to a widening of the capillary bed.

5. On either side, the tidal air presented a larger part of the vital capacity in the presence of a pneumothorax than before induction of the pneumothorax.

6. The results are illustrated by a representative case.

SUMARIO

1. En 18 enfermos se estudió la función pulmonar por medio de la espirometría y de la broncoespirometría antes y después de aplicar el neumotórax.

2. Las funciones pulmonares totales revelaron en sus cifras medias lo siguiente: Ligera disminución de la inspiración de oxígeno que correspondió a una leve baja del coeficiente del metabolismo basal; volumen respiratorio por minuto, entrada de aire y velocidad de la respiración, inalterados; equivalente de la aeración, leve aumento; capacidad vital (pulmonar), aire de reserva y aire complementario, considerable baja. Hubo una baja bien definida de la capacidad respiratoria máxima y de la

$$\frac{\text{capacidad respiratoria máxima}}{\text{por volumen por minuto}}.$$

3. La broncoespirometría reveló las siguientes alteraciones en el pulmón aplastado; considerable disminución de la inspiración de oxígeno; disminución algo menor del volumen por minuto y de la corriente de aire y aumento del equiva-

lente de la aeración, revelando empleo menos eficaz del aire de reserva y del aire complementario.

4. El pulmón contralateral se afectó en la forma siguiente: Aumento compensador de la inspiración de oxígeno; aumento menos pronunciado del volumen por minuto y de la corriente de aire y ligera disminución del equivalente de la ventilación, revelando mejor empleo del aire ventilado, y leve baja de la capacidad pulmonar, del aire de reserva y del aire complementario, probablemente debido a desviación del mediastino y ensanche del lecho capilar.

5. En ambos lados la corriente de aire representó una fracción mayor de la capacidad pulmonar después de ejecutar el neumotórax que antes.

6. Ilústrase el resultado con un caso típico.

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BRONCHOGRAPHY IN PULMONARY TUBERCULOSIS[1]

I. Normal or Questionable Roentgenographic Findings in Lungs and Positive Sputum

B. A. DORMER, J. FRIEDLANDER AND F. J. WILES

We are told from time to time of patients who have normal or questionable chests from the radiological point of view yet whose sputa are positive. Trudeau and Yeager (1) followed 100 such cases for from one to thirty years after discharge from hospital and only 7 died and, of these 7, one was reported as tuberculous.

We have always thought that if a sputum contained acid-fast bacilli and if these bacilli belonged to the pathogenic group then it ought to be possible to demonstrate radiologically some definite pathological change in the lungs.

We have recently studied several such cases and report 5 in this communication. The method of study was to take careful conventional antero-posterior radiograms and lateral and oblique films and, if nothing definite could be ascertained from these, to do bronchographic studies using a technique described by us (2).

In every case we succeeded in demonstrating sufficient abnormality in the lungs to account for a positive sputum.

CASE REPORTS

Case 1: E.442, E. M., aged twenty, cabin boy. This patient first became ill in September, 1941 while at sea. He had a cough for a few weeks and then became acutely ill with fever and haemoptysis. The fever gradually subsided and the haemoptysis did not recur.

On arrival in Durban he was admitted to another hospital where he remained on bed-rest for six months and his general condition steadily improved. On transfer to this hospital he was found to have no physical signs of pulmonary disease and the lung fields appeared clear on X-ray examination. The left root area was suspiciously large. His sputum was persistently positive and on culture a typical human organism was isolated.

Bronchoscopy was performed without finding any evidence of tracheobronchial tuberculosis; so, lipiodol bronchography was carried out with a view to finding the source of the positive sputum.

Figure 1, following lipiodol installation, shows a distorted and dilated bronchus behind the heart on the left, accounting for the positive sputum.

Following induction of left artificial pneumothorax, his sputum became negative.

Case 2: E.304, E. M., aged twenty-three, pupil pilot in Air Force. Prior to joining the Air Force he had been a laboratory technician who dealt with tuberculous sputa in large numbers every day. The present illness began in November, 1940 with a small haemoptysis. There were no further symptoms until April, 1941 when there was a further small haemoptysis and the sputum was found to contain tubercle bacilli, which proved to be a typical human strain.

On admission to the hospital he was in good general condition and there were no physical

[1] From the King George V Hospital for Tuberculosis, Durban, South Africa.

signs of disease in the lungs. X-ray film was clear. He was treated by bed-rest and at the end of four months his sputum was negative. At the end of six months he returned to work.

He remained fit for about a year, when he began to cough and spit and the sputum again contained tubercle bacilli. Again chest X-ray films showed no evidence of active lung disease and there were no abnormal physical signs. Lipiodol examination was therefore undertaken.

Bronchography (figure 2) revealed a dilated bronchus at the left apex and clavicular region, the apparent source of his positive sputum.

This patient has remained well for the last two years doing a full day's work. No change in the X-ray appearance has occurred. His sputum remains positive on every examination.

Case 3: C.275, I. M., aged twenty-six years, lorry driver. This patient had cough and haemoptysis early in 1939 and a positive sputum. He recovered rapidly and remained well until August, 1940 when he again began to cough and, a month later, had a small haemoptysis. He was then admitted to this hospital.

He was in good condition and the physical signs elicited were increased vocal resonance and fremitus on the right side. His sputum was negative on concentration.

Figure 3 reveals a small area of pneumonitis in the right infraclavicular region. In view of his previous history this was regarded as tuberculous but it was considered necessary to investigate by means of bronchography to examine in detail the right lung, especially the opaque area. Figure 4, a bronchogram, shows a completely normal bronchogram with the exception of a blocked bronchus feeding the area of pneumonitis.

There has obviously been a block of the feeding bronchus to a small tuberculous focus and a subsequent pneumonitis and eventual fibrosis with complete healing.

This patient has remained well and at work for the last two years. No changes have developed in the X-ray appearance and his sputum is always negative.

Case 4: E.470, E. M., aged thirty-six years, surveyor. In 1928 he had a right pleurisy with effusion and was in the hospital for six weeks. In 1937 he developed a left pleurisy with effusion and again was hospitalized for six weeks. Following the last attack of pleurisy he felt perfectly well until 1939, when he suddenly coughed up a "few spoonfuls of blood." He was admitted to a nursing home but, as his sputum was negative for tubercle bacilli, he was discharged after one week. He then developed early morning cough with sputum, but otherwise felt perfectly fit and was able to carry on a strenuous life as a land surveyor.

He was admitted to King George V Hospital in April, 1942 because his sputum was positive. His general condition was excellent. He was afebrile. Physical examination showed bronchial breath sounds at the right apex with increased vocal resonance in this area. Sputum contained tubercle bacilli, a typical human strain. A roentgenogram showed an obscured right apex and some diffuse mottling in the right infraclavicular region and an obscured extreme left apex. Because the evidence afforded by this film seemed inconclusive it was decided to investigate his right lung by bronchography. Figure 5 demonstrates bronchiectasis of the right upper lobe terminating in small cavities, an obvious source of the bacilli.

An artificial pneumothorax was attempted but failed. A one-stage right thoracoplasty was then done with resultant conversion of sputum.

He has remained well and at work for the last two years with a consistently negative sputum.

FIG. 1

FIG. 2

FIG. 3

FIG. 4

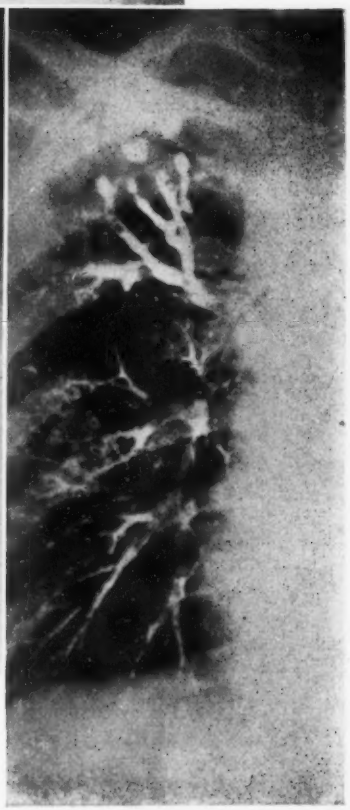

FIG. 5

Case 5: C.165, C. M., aged forty-six years, laborer. Present illness began in March, 1940 with an attack of dysentery, since when he has never felt well. In June, 1940 he complained of pain in his chest and began to cough producing a small amount of sputum daily. He was admitted to King George V Hospital in July, 1940. On admission his general condition was good and he was afebrile. No abnormal physical signs were detected in his chest. His sputum contained tubercle bacilli. A roentgenogram showed a doubtful lesion at the extreme right apex.

It was decided to investigate this lesion to ascertain the source of the tubercle bacilli. A bronchogram showed that the apical bronchus at the extreme right apex terminated in a cavity; the source of the bacilli was then obvious.

Right artificial pneumothorax was attempted but failed. Right extrapleural pneumothorax was established and the extrapleural space was filled with flexitissue. Later spread developed in the opposite lung. He is still alive but his sputum is positive.

DISCUSSION

We feel that every case in which a positive sputum is found and the X-ray findings do not clearly reveal the source of the bacilli and the lesion present should have a complete bronchographic examination.

It is interesting to note that the early lesion in tuberculosis is nearly always a bronchiectasis or a dilated bronchus terminating in a cavity. Probably bronchial block with subsequent pneumonitis and either abscess or bronchiectasis as a sequel is the common basic pathology in pulmonary phthisis.

SUMMARY AND CONCLUSIONS

Five cases of pulmonary tuberculosis with normal or doubtful X-ray evidence and positive sputa are described. Bronchographic studies were carried out in each case. Bronchograms revealed clearly the source of the tubercle bacilli in each case.

SUMARIO Y CONCLUSIONES

Descríbense cinco casos de tuberculosis pulmonar en los que los datos roentgenológicos eran normales o dudosos y el esputo positivo. En todos ellos se llevaron a cabo estudios broncográficos, y los broncogramas revelaron claramente la procedencia de los bacilos tuberculosos.

Acknowledgment

We have to thank Mr. Gibson, M.S.R., A.M.I.E.E., our technical assistant in the X-ray Department, for his help.

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BRONCHOGRAPHY IN PULMONARY TUBERCULOSIS[1]

II. Radiographic Black-out—Evaluation of Underlying Lesions

B. A. DORMER, J. FRIEDLANDER AND F. J. WILES

From time to time cases of pulmonary tuberculosis are encountered in which a conventional X-ray picture of the thorax fails to reveal the pathological status of the disease in one or the other lung owing to black-out of the diseased area. In this type of case a careful history and a meticulous physical examination often help one to evaluate the underlying pathological lesion. In most of them a careful series of tomographs will afford considerable help in formulating an exact diagnosis.

We have found that a bronchographic study of the blacked-out area of lung gives the clearest picture of pulmonary lesions. We will discuss 7 cases to show the value of this procedure which can be performed with the simplest tools in the smallest hospitals where a planigraph apparatus would be an impossible expense.

CASE REPORTS

Case 1: C.150, Indian male, aged nineteen years, shop assistant. He was treated by artificial pneumothorax on the left side in 1936 for unilateral pulmonary tuberculosis. This was abandoned after three months and he remained well until June, 1940, when he was admitted to King George V Hospital with a recurrence of the disease in the left lung and a positive sputum.

Pneumothorax was induced on the left side but was abandoned after three months owing to the development of a tuberculous empyema. After repeated aspirations the lung expanded, his temperature became normal, his general condition was excellent, but his sputum remained persistently positive. Physical examination suggested thickened pleura over the whole of the left lung.

It was considered necessary to demonstrate the actual pathological changes as clearly as possible in order to gauge the extent of operative interference necessary and to assess the origin of the positive sputum. Lipiodol examination was accordingly carried out. The usual roentgenogram (figure 1) shows an almost complete black-out of the left lung. A bronchogram (figure 2) shows distinctly that the upper clear area is a bronchiectasis and the lower dense area is a thickened pleura.

The pathological changes might have been deduced from a careful history but would never have been clearly demonstrated without a lipiodol investigation.

Case 2: E.326, European female, aged twenty-nine years, single. Her present illness began in Holland in 1929 with the sudden onset of right-sided pneumonia. This did not clear up and, after four months in the hospital, tubercle bacilli were found in the sputum. She then spent six months in a Swiss sanatorium. She returned home feeling comparatively fit and kept well for seven years with the exception of an irritating cough. She was admitted to a Dutch sanatorium at the end of this period and remained there for two and a half years. Here she had a right artificial pneumothorax attempted and a right phrenicectomy and a pneumoperitoneum performed. She became fairly well and

[1] From the King George V Hospital for Tuberculosis, Durban, South Africa.

arrived in South Africa in November, 1939 to try the effect of climate. She was admitted to King George V Hospital on June 14, 1941, after approximately eighteen months in the Free State.

Her general condition was poor. She was toxaemic, dyspnoeic and had a constant irritating cough. Sputum was foul smelling and pinkish. There was marked clubbing of the fingers. Physical examination of the chest showed dulness on the right side with signs of a large cavity at the upper lobe posteriorly. She died two months after admission.

Autopsy showed the right pleural cavity obliterated and the pleura was enormously thickened. The right lung was solid and fibrous. The right main bronchus was almost completely occluded at a point just beyond the carina. The upper lobe was occupied

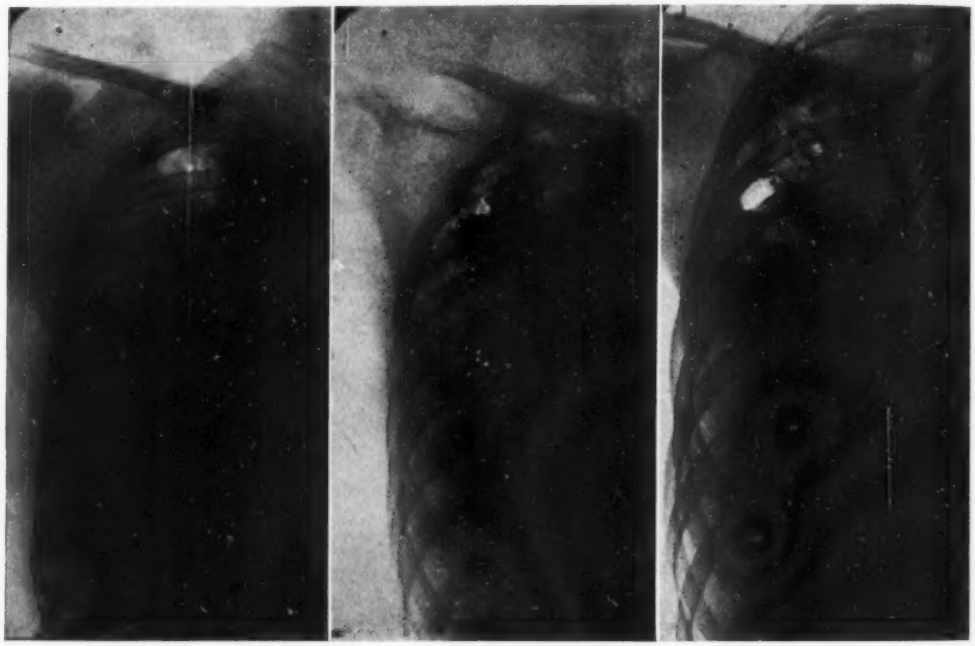

FIG. 1 FIG. 2 FIG. 3

by a thick-walled cavity. All the bronchi were distorted and there was no evident lung tissue.

A routine roentgenogram showed a black-out on the right side and a probable cavity at right midzone and periphery. Lipiodol revealed the right main bronchus almost blocked; a few blobs of lipiodol were traced through to the upper lobe cavity. In spite of extreme right tilt the trachea and left main bronchus remained filled.

In this case the pathological finding is evident on lipiodol examination and the only operative interference would have been a pneumonectomy, but the patient's condition did not warrant this.

One wonders if the bronchial block were not the prime factor in this case in the very beginning and if prompt investigation and operation might not have saved years of misery.

Case 3: E.441, European male, aged twenty-three years, merchant seaman. He began

to cough early in 1941 and gradually lost weight. Three months later he had an acute illness the symptoms, however, being mainly abdominal—epigastric pain and vomiting. He was sent to a hospital and the symptoms subsided after a few days. His chest was X-rayed because of his cough and tuberculosis was diagnosed. He was in the hospital in Port Said for nearly a year before being sent to Durban.

On admission to King George V Hospital he was in poor general condition and had dyspnoea with marked cyanosis. Physical signs were dulness over the whole of the left lung with poor air entry, except at the apex where there was loud bronchial breathing. Sputum was copious and contained tubercle bacilli. An X-ray film showed complete black-out on the left side with early disease at the right apex. Heart was displaced toward the left.

It was considered important to get an exact picture of the lesions on the left side in order to assess treatment. Hence bronchography was done. The bronchogram (figure 3) demonstrates clearly that the left lung is a system of cavities and that there is an enormously thickened pleura.

The sequence of events was probably a block of the main bronchus with a massive atelectasis—probably secondary organisms behind the block leading to a pneumonitis and eventual excavation, leaving a system of cavities lined with tuberculous granulation tissue.

A pneumothorax was performed on the right, preliminary to operative treatment on the left. However, the patient's condition has never warranted surgical procedures and he remains in *status quo*.

Case 4: E.174, European male, aged thirty-two years, tram conductor. He started to cough and spit in December, 1939 and was admitted to King George V Hospital in April, 1940. His sputum was then positive and X-ray examination revealed infiltration with a cavity in the right infraclavicular region. A pneumothorax was induced and a satisfactory collapse obtained. In November, 1940 a pleural effusion developed and this was followed by obliterative pleuritis. The lung eventually expanded completely, leaving him afebrile, in good general condition and with a negative sputum. Physical examination suggested thickened pleura over the lower part of the right lung with the heart drawn over to the right. A roentgenogram showed that the right lung was completely obscured following obliteration of pneumothorax.

It was considered necessary to get an exact idea of the residual lesions in the right lung before the patient was discharged. A bronchogram was obtained. This (figure 4) demonstrates a thickened pleura, a small collection of fluid at the base and a blocked bronchus in the infraclavicular region in the area of the original lesion. This gives one a much clearer and complete impression of the essential lesions in this case than a conventional X-ray film.

Case 5: C.134, Indian female, aged twenty-two years, housewife. She had an acute illness in 1937 accompanied by cough and fever. This lasted some weeks but she recovered completely and was well until March, 1940, when she again became acutely ill and again had a cough with sputum and high temperature. Two months later she was admitted to King George V Hospital. She was in poor general condition. Physical signs were those of a large cavity in the upper part of the left lung. Sputum contained tubercle bacilli. A roentgenogram showed that the left side was obscured and that there probably was cavitation in the upper lobe. There were scattered lesions on the right.

A bronchogram (figure 5) was done to estimate the lesion of the left lung and the amount

of possible surgical interference. This showed that the left lung was replaced by a system of cavities and that there was an enormous thickening of the pleura.

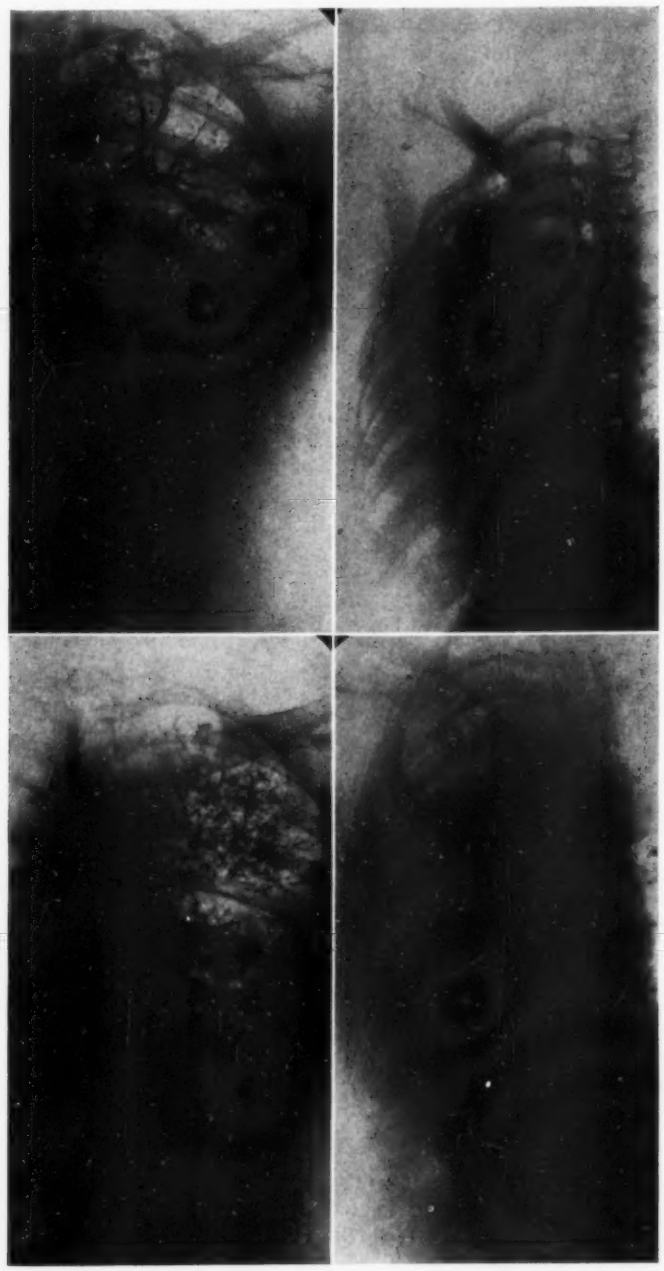

FIG. 4

FIG. 5

FIG. 6

FIG. 7

The sequence of events was probably a block of the main bronchus, atelectasis—infection and liquefaction—leading to the present condition.

A thoracoplasty was performed on the left side—seven ribs in two stages. She developed a spontaneous pneumothorax on the right but recovered. She has been fit for two years, although her sputum has been positive on two occasions since her thoracoplasty.

Case 6: G., native male, aged thirty-nine years, houseboy. The case is one of tuberculous pleurisy with effusion. An antero-posterior conventional picture showed effusion on the right. A bronchogram (figure 6) illustrates the compression of the lung by fluid in the pleural cavity. The bronchial and alveolar compression at the base should be noted.

Case 7: E.330, European female, aged thirty-five years, housewife. Her present illness began ten years ago with vague symptoms of feeling "out of sorts" and cough. This was diagnosed as influenza and she remained in bed one month. Her cough persisted after this illness and she was X-rayed and tuberculosis was diagnosed. She was admitted to a sanatorium and a left artificial pneumothorax was induced. This was abandoned after three months because of pleural fluid. A left phrenicectomy was done and she was discharged as fit after twelve months in the hospital. Five years ago she had an haemoptysis and was admitted to the hospital where, after three months of bed-rest, she was discharged as well.

Three years ago she accompanied her husband to the Middle East. She felt quite well except for an early morning cough. Five months ago she was evacuated to Durban where her sputum was examined and found to contain tubercle bacilli. She was admitted to King George V Hospital on June 25, 1941. On admission her general condition was fair. She had morning cough and sputum which was positive. Her evening temperature was up to 99°F. There was well marked clubbing of the fingers. Physical examination showed flattening of the left chest with dulness, increased vocal resonance and whispering pectoriloquy. The apex beat was displaced to the left. A roentgenogram showed an almost complete black-out on the left side. A bronchographic examination was done and revealed that the left lung area was occupied by one large cavity and that the pleura was enormously thickened (figure 7).

DISCUSSION

A conventional X-ray film, although an essential in the diagnosis of pulmonary disease, is not sufficient in many cases, especially those in which a part or the whole of the lung is obscured by previous inflammation of the pleura or following artificial pneumothorax or other forms of therapy.

Bronchography and tomography should be utilized in such cases. In the small institution where tomographic apparatus is not available, bronchography will often act as a substitute and provide a clear detailed view of the lesions underlying blacked-out areas of lung.

We are struck by the frequency of gross cavitation in a large number of the cases described and feel that block of a main bronchus with subsequent excavation of large portions of a lung is a not uncommon sequel to pulmonary tuberculosis. In view of the size of the cavity and the great thickening of the pleura it appears that thoracoplasty in such cases would fail.

SUMMARY AND CONCLUSIONS

Seven cases of radiographic black-out of one lung field were studied by bronchography. The bronchograms in each case revealed in clear detail the lesions

underlying the obscure area. The majority of the cases showed gross cavitation probably resulting from block of a main bronchus.

This method of study of pulmonary lesions is considered of value in diagnosis.

SUMARIO Y CONCLUSIONES

Por medio de la broncografía, estudiáronse siete casos de oscurecimiento radiográfico de un campo pulmonar. Los broncogramas revelaron invariablemente y con todo pormenor la patología subyacente en la zona oscurecida. La mayoría de los casos mostraban cavernas macroscópicas, probablemente debidas a la obstrucción de un bronquio mayor.

Este método de estudio de las lesiones pulmonares posee valor reconocido en el diagnóstico.

Acknowledgment

We wish to thank Mr. M. Gibson, A.M.I.E.E., M.S.R., for his help in the X-ray work.

INJURIES OF THE THORAX IN BATTLE CASUALTIES[1]

L. KRAEER FERGUSON[2] AND ROBERT B. BROWN[3]

Our experiences with thoracic injuries in battle casualties was gained while on duty aboard a hospital ship in the South Pacific. The patients whom we attended were, with few exceptions, battle casualties from the Solomon Island campaign. As one would expect from such amphibious operations, all branches of our participating forces are represented in this group.

The patients were received aboard the hospital ship from several sources. Those from the original landings in the Solomons arrived aboard transports about seven days after they were injured. As facilities in the forward and battle areas were better developed evacuation by air became possible. The patients were evacuated first to a forward base from which they later came aboard the hospital ship, arriving any time from twelve hours after injury to as long as four weeks after injury.

The time interval between injury and admission was as follows:

Less than 1 week	40 cases
1 to 2 weeks	39 cases
2 to 3 weeks	12 cases
3 to 4 weeks	2 cases
Interval not accurately known	7 cases

Many of these cases had received only emergency treatment, whereas others had received excellent definitive care and came aboard as convalescents.

FREQUENCY OF CHEST INJURIES

In a group of 3,333 surgical casualties which came aboard the hospital ship in a period of six months, there were 234 patients with chest wounds which represented about 7.4 per cent of the wounds. This percentage varied a great deal with the battle conditions. For instance, those who reached the ship from the late engagements in the Gilberts had an incidence of chest wounds of 16 per cent. When the chest wounds were studied according to injuring agent they were found to be caused by shell fragments, bullet wounds, contusions and saber and bayonet wounds.

Of 234 patients with chest wounds the distribution was as follows:

INJURING AGENT	NUMBER OF CASES	THROUGH-AND-THROUGH WOUNDS	INTRATHORACIC WOUNDS
Shell fragment	117	4	50
Bullet	95	40	59
Saber and bayonet	15		3
Contusion	7		4
Total	234	44	116

[1] Presented before the Medical Section at the 40th annual meeting of the National Tuberculosis Association, Chicago, Illinois, May 11, 1944.

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Those from various types of fragments, such as shell, grenade, bomb, often produced multiple wounds of large size. Whereas those from bullets, bayonets or saber usually produced single small or small through-and-through wounds. Of the 234 wounds, 116, or about 50 per cent, produced intrathoracic injuries. It was evident in studying these wounds that the chest wall produced an effective measure of protection against intrathoracic injury. This was especially true of missiles of lower velocity, such as those due to grenade and bomb fragments. In addition, the rib cage often produced a sufficient deflection of bullets or fragments to protect the underlying chest even though fractures might occur.

In 117 shell-fragment wounds there were 50 complicated by intrathoracic dfficulty (52.8 per cent), where as in 95 bullet wounds, a missile of high velocity, intrathoracic injury occurred in 62.1 per cent of the cases. Furthermore, as may be seen from the tabulation, the incidence of through-and-through wounds of the chest was much higher in bullet wounds than in fragment wounds. The presence of evident intrathoracic injury, either due to a through-and-through wound or retention of foreign body in the lung, did not necessarily produce many pulmonary findings or symptoms. We have seen patients with through-and-through bullet wounds of the chest whose only symptom was spitting of blood for two or three days and without any X-ray evidence of pulmonary reaction. Other cases with retained grenade or sheel fragments had haemoptysis for a few days with a minimal reaction around the foreign body as shown by X-ray examination and without demonstrable physical findings in the lung. We selected 100 consecutive patients in whom there was unquestionable clinical or roentgenological evidence of intrathoracic lesion. All those patients were eliminated whose injuries were superficial and confined to the chest wall itself.

TYPE AND LOCATION OF WOUNDS

Wounds have been classified both as to the type lesion produced and as to the wounding instrument, as follows:

A. Closed Wounds:	
Blast or blunt trauma	1 case
Thrown from horse	1 case
Fall—8 ft.	1 case
B. Open Wounds (nonsucking):	
Bullet	47 cases
Shrapnel	38 cases
Bayonet and saber	2 cases
C. Open Wounds (sucking):	
Shrapnel	4 cases
D. Data not adequate for classification:	6 cases

In 3 cases there was no open or visible wound of the thoracic wall itself. The first of these patients was injured when his ship was sunk. He was admitted to us with a diagnosis of immersion blast, but further questioning revealed that he had been struck on the right upper chest with a piece of wreckage. Slight haemoptysis was present and there were a few scattered râles on the injured

side. Roentgen examination revealed a fractured first rib on the right with a little fluid in the sulcus.

The second patient in this group was thrown from a horse and in addition to fracturing several ribs he developed a right pleural effusion and a pneumonia on the left.

The third patient suffered a fall aboard his ship. He fractured several ribs and the third lumbar vertebra. He developed subcutaneous emphysema and a right hydrothorax.

The majority of the open, nonsucking wounds were due to bullets. They were usually through-and-through with relatively small wounds of entrance and exit. All wounds produced by exploding shells, hand grenades, bombs, flying debris, etc., have been grouped together as shrapnel wounds. Thirty-eight of these were nonsucking wounds and 4 were sucking wounds. The sucking wounds as a group did poorly. Three large ones were already infected by the time they reached the ship. They were treated by packing and covering with an air-tight dressing of vaseline gauze or rubber dam until the reaction to infection had stabilized the mediastinum sufficiently to allow wide-open drainage. These patients were quite sick and in addition to sulfonamides received liberal dosage of morphine, oxygen as indicated and supportive treatment which included blood transfusions and special high caloric diets. One small uninfected sucking wound was closed surgically with immediate relief of symptoms and primary healing.

There were 2 stab wounds, one a bayonet and the other a saber wound. The patient with the bayonet wound of the right lower chest died suddenly of a pulmonary embolus late during a previously uneventful convalescence. At autopsy the clinical diagnosis of haemothorax was confirmed and in addition it was found that the bayonet had passed through the diaphragm and into the liver. A small subdiaphragmatic collection of bile-stained fluid was present.

In 32 cases there was a single wound present and in 17 cases the wounds were multiple. In the remaining cases the wounds were through-and-through and multiple in the sense that there was both a wound of entrance and a wound of exit.

Wounds of the posterior chest were more frequent than anterior ones and in a few instances the wounding missiles entered the lateral wall on one side or the other. The through-and-through wounds usually traversed the chest in an antero-posterior plane but a few passed through from side to side.

SYMPTOMS

The presenting symptoms were as follows:

Dyspnoea	63 cases
Pain	51 cases
Haemoptysis	42 cases
Subcutaneous emphysema	12 cases
Cyanosis	3 cases

Dyspnoea undoubtedly was due in many cases to actual impairment of respiratory function. In others pain and apprehension were largely responsible for the difficulty in breathing.

Pain was of several types. That of the wound itself was often quite negligible. Pleuritic type pain was frequently observed. Severe pain of intercostal nerve irritation or injury was not infrequent and required novocaine injection for relief in some instances.

Haemoptysis never reached alarming proportions. Subcutaneous emphysema was often quite extensive and in one case involved the neck, chest, both arms down to the wrists, abdomen and scrotum. Cyanosis was recorded as being present in only 3 cases, but it is our feeling that mild degrees of cyanosis were probably overlooked in many.

VITAL SIGN

The charts of temperature, pulse and respirations have been studied and the data obtained have been summarized in tables 1, 2 and 3. The cases have been

TABLE 1

Temperature

	MEAN HIGH	INDIVIDUAL HIGH
Admitted first week after injury	100.7	103.8
Admitted second week after injury	100.5	104.0
Admitted third week after injury	101.0	103.6
Admitted fourth week after injury	2 cases—no elevation	

TABLE 2

Pulse rate

	MEAN HIGH	INDIVIDUAL HIGH
Admitted first week after injury	100	160
Admitted second week after injury	94	128
Admitted third week after injury	99	120
Admitted fourth week after injury	2 cases—normal	

divided into subgroups on the basis of the time interval between injury and admission. The means for these groups are figured on the highest temperature, pulse rate and respiratory rate recorded for each patient during the period of observation, which in most instances was one week or less. The highest single reading for each group is listed as indicated.

In table 4 are contained similar data for the 12 infected cases treated as a separate group.

It is certainly noteworthy that in this group of 100 cases with a relatively small percentage of complicating infections a definite febrile response persisted for as long as three to four weeks after injury. It is true that the mean for the infected cases alone is slightly higher than that for the entire group, but it is doubtful whether this difference is great enough to be of any diagnostic signifi-

cance. Concomitant injuries to other parts of the body may have contributed to the fever in some. In many instances, sulfonamides may have been responsible for an elevation of temperature, and in one or 2 cases malaria; these considerations do not alter the fact that persistence of fever is to be expected, even in uncomplicated cases of intrathoracic injury, especially with blood in the pleural cavity. This finding should not rush us into hasty and unwarranted therapeutic procedures.

TABLE 3

Respiratory rate

	MEAN HIGH	INDIVIDUAL HIGH
Admitted first week after injury	24	50
Admitted second week after injury	23	50
Admitted third week after injury	23	40
Admitted fourth week after injury	2 cases—normal	

TABLE 4

Vital signs—12 infected cases

	MEAN HIGH	INDIVIDUAL HIGH
Temperature	101.6	103.2
Pulse rate	109	130
Respiratory rate	30	50

TABLE 5

Blood counts

	MEAN	
Red cells	3,500,000	Lowest individual count—1,700,000
White cells	11,200	Highest individual count— 37,800
Haemoglobin	72 per cent	Lowest single value—42 per cent

BLOOD COUNTS

Nearly all cases had complete blood counts on admission. Several patients had received plasma or whole blood prior to admission. Table 5 contains the data obtained from an analysis of the blood counts.

It has already been stated that very few cases were in shock on admission and few emergency transfusions were required. On the other hand, whole blood was given as soon as circumstances permitted to those whose clinical picture or blood count indicated a moderate to severe grade of anaemia.

As compared to the quite definite febrile response the increase in leucocytes was not marked. Patients taking sulfonamides systemically received a complete blood count every other day and in one or two instances the drug was stopped because of a progressively developing leucopenia. The high leucocyte

count of 37,800 was obtained in a patient who had had a thigh amputation for gas gangrene of the lower leg just prior to admission to the ship.

TYPE OF INTRATHORACIC INJURY

The criterion for inclusion of a case in this group was that the patient show unmistakable clinical or roentgenological evidence of an intrathoracic lesion in addition to whatever other injuries might be present A listing of the types of lesions encountered follows:

1. Hydrothorax (probably haemothorax)	55	
2. Pneumothorax	2	
3. Combination of 1 and 2	22	
4. Pneumonia and pneumonitis	17	
5. Hydropneumopericardium	1	
6. Mediastinal emphysema	1	
7. Contusion and interstitial haemorrhage	1	(autopsy)
8. Atelectasis	2	
9. Pleural thickening	2	
10. Foreign bodies	20	

In 20 cases there was evidence of an intrapulmonary lesion, many of these were due to reaction around a foreign body; 2 were atelectatic; and in one patient who died there was interstitial haemorrhage into a contused right apex demonstrated at autopsy.

In 20 patients intrathoracic foreign bodies were demonstrable. These were bullets and other pieces of metal of various sizes and shapes.

One patient with a thoraco-abdominal injury exhibited peculiar clicking and crunching extra-cardiac sounds over the precordium which were attributed by the examiner to mediastinal emphysema. Unfortunately these signs had disappeared before a confirmatory roentgenological examination could be made. Two cases which were admitted to the ship late in convalescence showed pleural thickening only.

COMPLICATIONS AND CONCOMITANT INJURIES

The following complications and accompanying injuries were observed:

A. Infection:		
1. Sucking wounds	3 cases	
2. Shrapnel wounds	4 cases	
3. Bullet wounds	5 cases	
B. Haemorrhage:		
1. Secondary haemorrhage	1 case	
C. Fracture of thoracic cage:		
1. Ribs	43 cases	
2. Scapula	4 cases	
3. Spine	5 cases	(3 with injury to the spinal cord)
	2 injuries to spinal cord	without demonstrable fracture

D. Miscellaneous:
1. Fracture of extremities
2. Multiple soft tissue wounds
3. Abdominal wounds
4. Injuries to blood vessels (pulsating haematomata)

There was definite evidence of infection in 12 cases. As already pointed out, 3 of the sucking wounds were infected, one with anaerobic gas-forming organisms. In addition, 4 more of the shrapnel wounds and 5 of the bullet wounds exhibited varying degrees of infection. One of these was frank empyema requiring drainage and subsequent removal of a large foreign body. One case had *Staphylococcus aureus* in the bloody fluid removed from the chest by aspiration. One patient had mediastinal gas gangrene. In the remaining 6 cases the infection seemed to be confined to the superficial aspects of the wounds and apparently did not involve the intrathoracic content.

Secondary haemorrhage occurred in one case, but fortunately the bleeding vessel was superficial in the wound and was easily controlled by ligature.

TREATMENT PRIOR TO ADMISSION

The very conditions under which primary or emergency treatment is often administered make the keeping of complete records most difficult. However, we have collected what data are available and present them as follows:

Treatment Prior to Admission

1. Sulfonamides ..... 28 cases
2. Thoracocentesis ..... 12 cases
3. Oxygen ..... 5 cases
4. Plasma and blood ..... 28 cases
5. Surgery ..... 22 cases
   a. Closure of sucking wounds
   b. Debridement
   c. Removal of foreign bodies
   d. Thoracotomy

While in only 28 cases there was definite evidence that a sulfonamide had been administered systemically, in nearly every case one of these drugs, usually sulfanilamide, had been used locally in the wound.

Surgery had been performed in 22 cases, but none of these had undergone major surgical procedures as indicated above.

TREATMENT ABOARD SHIP

Treatment aboard ship was given as follows:

1. Sulfonamides, systemically ..... 17 cases
2. Thoracocentesis ..... 10 cases
3. Oxygen ..... 2 cases
4. Transfusions ..... 16 cases
5. Surgery
   a. Removal of 4 foreign bodies from thoracic wall
   b. Removal of 1 foreign body from lung
   c. Thoracotomy—1 case
   d. Novocaine injections—intercostal nerve pain

All open wounds were dressed with microcrystalline sulfathiazole. This was sprayed lightly on superficial wounds from a power blower or was instilled into deep wounds as an aqueous suspension. Sulfonamides were administered systemically to only 17 of this group of 100 patients, including 7 of the 12 infected cases. The 5 patients with infection who did not receive one of these sulfa drugs were those in whom the infection was thought to be superficial in the wound. Follow-up studies show that this individualization of treatment in the infected group may not have been justified, since 3 of these patients not receiving sulfonamides developed empyemata after leaving the ship.

No major surgical procedures were performed. One frank empyema required thoracotomy and later removal of an intrapleural foreign body. One sucking wound was closed by suture; 4 metallic foreign bodies were removed from the thoracic wall and one from the lung itself. This latter case was interesting. A tremendous piece of shrapnel had entered the chest beneath the right clavicle anteriorly, had traversed the lung, and had lodged in the posterior wall of the cage but still projected into the lung. The head of the projectile had completely cooked the surrounding pulmonary tissue and that of the thoracic wall. Incision was made through the blackened overlying skin and the foreign body was removed without any bleeding whatsoever.

A few novocaine injections were used to relieve intercostal nerve pain and paraesthesia.

FATALITY

Two of our patients died aboard the ship, a fatality rate of 2 per cent. The one patient with a bayonet wound died of a pulmonary embolus late in convalescence. The other with a shrapnel wound of the neck died of gas gangrene of the mediastinum within three hours after admission.

DISCUSSION

Before proceeding to a discussion of the data presented we wish to call attention to the brief outline of the treatment of thoracic injuries in general (table 6). In this outline we have indicated by asterisks those groups into which our patients fall. This is for the purpose of showing just where our cases fit into the general scheme of things in order that we may properly evaluate our observations. We must not make the mistake of concluding that our fatality figure of 2 per cent represents the fatality of thoracic injuries as a class of battle casualties.

None of our patients were admitted in deep shock or with gross unrelenting haemorrhage. These conditions either were adequately controlled at front-line stations or the patients did not live to reach the ship.

Another group with a high fatality are the thoraco-abdominal injuries. A few of these cases were received aboard ship, but not for primary treatment. They were those patients who had received the indicated emergency abdominal surgery in advanced hospitals and who had been fortunate enough to survive.

On occasion we were called upon to render prompt treatment for the relief of cardiorespiratory disturbances due to tension pneumothorax, intrapleural haemor-

rhage and sucking wounds. No cases of "stove in chest" or cardiac tamponade were encountered. Primary surgical treatment of the wound itself had either been performed or was not indicated by the time the patients reached us.

Conservation has been stressed in the handling of these patients. Systemic administration of sulfonamides was instigated or continued only in selected cases in which it was felt there was a definite indication from the standpoint of prophylaxis against infection or for the treatment of infection already present. Blood transfusions were given to the more severely anaemic patients or on a few occasions as a supportive measure to seriously ill patients. The mere presence of fluid in the chest was not considered an indication for thoracocentesis. This procedure was reserved for the relief of signs and symptoms due to profound

TABLE 6

Outline of treatment—thoracic injuries

A. Conditions Requiring Emergency Treatment:
  1. Shock
  2. Gross, unrelenting haemorrhage
  3. Those producing profound disturbance in intrathoracic pressure relationships
    *(a) Tension pneumothorax
    *(b) Intrapleural haemorrhage
    *(c) Sucking wounds
    (d) "Stove in chest"
    (e) Mediastinal emphysema
    (f) Cardiac tamponade
  4. Thoraco-abdominal injuries
*B. Primary Surgical Treatment of the Wound.
*C. Postoperative and Convalescent Care:
  1. Sulfonamides
  2. Thoracocentesis
  3. Transfusions
  4. Oxygen
*D. Treatment of Complications and Elective Procedures:
  *1. Removal of foreign bodies
  *2. Thoracotomy
  3. Thoracoplasty
  *4. Control of secondary haemorrhage

disturbance in intrathoracic pressure relationship or for diagnosis when infection was suspected. Oxygen therapy was seldom required and, as our data indicate, surgical interference was minimal. Foreign bodies were removed only when easily accessible or in the presence of infection.

An attempt was made to obtain follow-up data on all patients presented; in only 55 instances were we successful. The follow-up period is relatively short, varying from one to four months from the time the patient left the ship. The data obtained are as follows:

Eight of the 55 patients had been returned to duty as cured; 35 had been evacuated to the United States improved but not yet ready for full duty. In this group convalescence was progressing satisfactorily. Ten of the group still

had or had had draining empyema cavities. In 5 of these, infection had been recognized aboard ship; 2 were infected sucking wounds; 2 had had dirty wounds of the chest wall; and in one case we had demonstrated *Staphylococcus aureus* in serosanguineous fluid aspirated from the chest. In the other 5 cases infection was not present or had not been recognized while the patients were under our care. However, 3 of this latter group had been selected by us for prophylactic sulfonamide therapy.

Two patients died after leaving the ship. One death followed operation for a complicating traumatic carotid aneurysm, pulsating haematoma of the right side of the neck. The other patient who died was recognized aboard ship as having infected chest wounds and a haemothorax. His condition was fair on transfer. He developed infection in his haemothorax and in spite of repeated thoracocentesis and supportive treatment, including oxygen therapy, he died twenty-two days after injury. Autopsy revealed a severed second intercostal artery and vein, a torn axillary vein, a massive purulent haemothorax, a lacerated apex of the lung and fractures of the second and third ribs, all on the right side.

SUMMARY

1. Thoracic injuries observed aboard a hospital ship in the South Pacific are reviewed.

2. Thoracic injuries amounted to 7.4 per cent of 3,333 surgical casualties.

3. Primary treatment in these patients had been emergency and in many cases definitive treatment had been given to these patients before they had been admitted to the hospital ship.

4. One hundred patients with intrathoracic injuries were studied while aboard the ship and in this group there were 2 deaths. The most frequent symptoms were dyspnoea, which was often due to pain rather than interference with respiratory function; pain, frequently caused more by the accompanying wound and fracture than by the intrapleural injury; and haemoptysis. The most characteristic finding in patients with intrapleural injuries was a persisting febrile reaction. Infection was found in 12 per cent of the cases. Other common complications were compound fractures of the ribs and scapula (47 cases), injuries to the spinal cord and vertebra and associated injuries to other parts of the body. Treatment of these latter cases aboard the hospital ship was conservative; mechanical cleansing of the wounds by irrigation and local application of microcrystalline sulfathiazole, aspiration of the chest was performed only for dyspnoea or for diagnosis when infection was suspected. It was our experience that repeated aspiration made these patients worse, with increased pain and increased temperature. In addition, the presence of associated injuries made a conservative regimen seem advisable. Transfusions were frequently used as a supportive measure.

5. Follow-up of 55 patients showed that 8 had been returned to duty and 35 improved, but not ready for full duty. There were 2 deaths in patients after they had left the ship from complications rather than from the intrathoracic injury itself.

SUMARIO

1. Repásanse aquí ciertas lesiones torácicas observadas a bordo de un buque-hospital en la región del Sur del Pacífico, las cuales representaron 7.4 por ciento de 3,333 accidentes torácicos.

2. El tratamiento primario de esos enfermos había sido de urgencia, pero en muchos casos definitivo antes de su recibo en el buque-hospital.

3. Mientras estaban a bordo se estudió a 100 enfermos con lesiones intratorácicas, habiendo sobrevenido 2 muertes en el grupo. Los síntomas más frecuentes fueron: disnea, a menudo debida a dolor más bien que a obstrucción de la función respiratoria; dolor, frecuentemente ocasionado por la herida y fractura concomitantes más bien que por la lesión intrapleural; y hemoptisis. En los casos intrapleurales el hallazgo más característico consistió en una persistente reacción febril. En 12 por ciento de los casos se observó infección. Otras complicaciones frecuentes fueron: fracturas compuestas de las costillas y omóplatos (47 casos); lesiones de la médula espinal y las vértebras, asociadas con lesiones de otras partes del cuerpo. El tratamiento de estos últimos casos a bordo fué conservador, limpiándose mecánicamente las heridas por medio de lavados y aplicaciones locales de sulfatiazol microcristalino, reservándose la aspiración torácica para los casos de disnea o para el diagnóstico cuando se sospechaba infección, habiéndose observado que las aspiraciones repetidas empeoraban el caso por acrecentar el dolor y la temperatura. Además, la presencia de otras lesiones parecía imponer un régimen conservador. Como medida tónica se empleó frecuentemente la transfusión.

4. La observación subsecuente de 55 enfermos reveló que 8 habían reanudado sus tareas habituales y 35 habían mejorado, pero no se hallaban aún en aptitud de reanudar su trabajo completo. Después de abandonar el buque sobrevinieron dos muertes en enfermos debido a complicaciones más bien que a la lesión intratorácica misma.

DISCUSSION

Lieut. Colonel Richard H. Meade, Medical Corps, Army of the United States, Memphis, Tennessee: I consider it an honor to open the discussion of this interesting report on chest injuries as observed in the South Pacific, particularly as I have had occasion to see the late good results of this early treatment. Those of us working in the Army general hospitals in this country have been constantly impressed by the excellent care the wounded from all the areas of the war have had before getting to us. I have been especially impressed by the good results obtained by the group headed by Captain Ferguson and Commander Brown. The treatment the men have gotten before coming to us has usually been so complete that we have had little to do to help them on to final healing. The only type of case I especially have seen that has needed intervention on my part has been an occasional case of neglected haemothorax. In certain instances, when the patient has reached us with an untapped haemothorax of several months' duration, or one that has been ineffectually aspirated, it has been necessary to do radical operations to restore the collapsed lung to its proper condition. In these instances, decortication of the lung has proved highly successful. If the blood is removed from the pleural cavity during the first few days and the cavity kept dry by repeated aspirations, the lung reëx-

pands promptly and disability from empyema or chronic fibrothorax is rare. I think it is important to emphasize this point.

In the last war, the management of open wounds of the chest was the most outstanding contribution. So well has the lesson been learned that open wounds of the chest must be closed at once, that, in this war, everyone, from stretcher bearer to chief surgeon, is aware of its importance. Captain Ferguson has reported several cases of interstitial emphysema he observed and I have patients who had this complication soon after their wounds were treated, due to the overzealous closure of a sucking wound of the chest associated with an injured lung. When air is escaping from the lung, it is important to provide for closed drainage of the chest when the sucking wound is closed.

In closing, may I again say how strongly I feel that our men overseas are getting such treatment that when they reach us, who are stationed in the hospitals in this country, there are few problems for us to face. This report of Captain Ferguson and Commander Brown well illustrates the fine early treatment our wounded are receiving.

ROUND DENSITIES WITHIN CAVITIES[1]

Lung Lesions Simulating the Pathognomonic Roentgen Sign of Echinococcus Cyst

I. D. BOBROWITZ

Very little has been written about densities within cavities. The standard text-books of tuberculosis, chest diseases and roentgenology make no mention of it. However, the appearance in the roentgenogram of a round uniformly dense focus, surrounded by a crescentic air space and membrane, has been considered pathognomonic of a pulmonary echinococcus cyst (1). In discussing the pathognomonic sign of a pericystic air space, Evans (1) has stated that "Dévé (2) observed a similar picture in a case of aspergillosis in which a mass of fungi, a mycelial calculus, almost filled a large bronchiectatic abscess leaving only a thin layer of air."

Stivelman and Malev (3) have presented a case where the X-ray film showed a large, dense, irregular mass within the lower aspect of a thin-walled tuberculous cavity. Necropsy revealed the cavity to be two-thirds filled by a mass which was an aneurysmal dilatation of a branch of the pulmonary artery. (Roentgenographically, this case simulated pulmonary echinococcosis.)

The purpose of this paper is to present two unusual and very interesting cases of round densities within bronchiectatic cavities. In one patient the cavity contained inspissated pus in the shape of a round mass, and in the other a blood clot formed the intracavitary density. From a roentgenological point of view, these cases resembled echinococcus cysts.

CASE REPORTS

Case 1: The patient, *L. K.*, a thirty-nine year old, married, unemployed American male Negro, was admitted to the Municipal Sanatorium, Otisville, New York, on February 19, 1942. His health was good until June, 1940 when he developed pneumonia. He was admitted to Kings County Hospital June 27, 1940 with a history of an upper respiratory infection of three weeks' duration, followed by chills, fever and chest pain. A chest film of July 2, 1940 revealed pneumonic consolidation of the right upper lung field. By August 20, 1940 an X-ray film showed a marked decrease of the lesion which was almost entirely confined to the apex. Repeated sputa and gastrics were negative for tubercle bacilli. The patient left against advice August 22, 1940 and went to North Carolina. Slight cough and expectoration continued. He returned to New York City in 1942 and visited a clinic January 18, 1942 and sanatorium care was recommended. He was admitted here February 19, 1942 with complaints of cough, expectoration and fatigue. Physical examination revealed dulness and moist râles in the right apex anteriorly and posteriorly.

The X-ray film (figure 1) was unusual. In the right apex, and partly hidden behind the medial third of the clavicle, was a bronchiectatic cavity. The cavity consisted of a central, homogeneous, well defined, dense, round shadow, 2.5 cm. in diameter, surrounded by a narrow air space and a thin wall. Linear infiltration and fibrotic lines extended

[1] From the Municipal Sanatorium, Otisville, New York (one of the institutions of the Department of Hospitals of the City of New York).

from the wall superiorly and medially. The central dense body within the cavity was apparently an accumulation of inspissated pus and the concentric area of increased illumination surrounding it was air in the cavity. This solid mass and encircling air space provided a roentgenological appearance that could be considered pathognomonic of a pulmonary echinococcus cyst.

All sputa, gastrics and cultures were negative for tubercle bacilli. A two-plus reaction was obtained with 0.1 mg. OT.

An iodized oil instillation of the right upper lobe on May 20, 1942 did not provide any additional information as the oil did not reach or fill the cavity.

A tomographic study (figure 2) delineated the entire cavity. The lesion was most clearly defined at a distance of 8 cm. from the anterior chest wall. The central density measured 2.5 cm. in diameter and the surrounding air space appeared as a narrow halo-like highlight. The cavity wall was well defined and thin, and could be seen in its entirety. The inspissated mass had a somewhat irregular edge in this view, but in the routine films in upright position and in apical films, it appeared as a smooth, uniformly dense, clear-cut shadow. This picture could also be considered as radiographically pathognomonic of echinococcus cyst.

A film on August 3, 1942 showed no changes. The patient's condition remained the same until August 14, 1942 when he became acutely ill with increased cough, expectoration of copious amounts of greenish-yellow foul-smelling sputum, chilliness, sweats and pain in the right chest. The temperature was 104°F.; pulse, 110; respiratory rate, 24. Physical examination revealed moist râles in the right upper lobe.

A "portable film" August 15, 1942 showed a new diffuse, soft, coalescent infiltration in the right upper lobe extending from the first to the third anterior rib. However, the round density within the right apical cavity was now no longer visible and, above the clavicle and first rib, the empty cavity was outlined by a circular area of rarefaction, 3 cm. wide (figures 3 and 4). What had apparently happened was that the inspissated pus (the intracavitary dense, round shadow) had liquefied. The cavity then emptied itself and while most of the pus was expectorated, accounting for the sudden appearance of copious, foul sputum, some was aspirated into the right upper lobe causing the acute pneumonic infiltration.

On August 15 a Gram stain of the sputum showed many pus cells and Gram-positive cocci in chain and tetrad formation and Gram-negative rods. No pneumococci were seen and a mouse inoculation was done but was negative. The peritoneal washings from the injected mouse revealed Gram-negative rods and cocci. During the acute phase, four twenty-four-hour concentrates of sputum were negative for tubercle bacilli. An anaerobic culture was also negative. The blood showed a moderate leucocytosis.

FIG. 1. (Upper left) Case 1. May 8, 1942. Bronchiectatic cavity in the right apex with a central dense shadow surrounded by a narrow air space and thin cavity wall.

FIG. 2. (Upper right) Case 1. June 25, 1942. Tomographic study. Cavity at level of fourth posterior rib. The intracavitary density surrounded by a narrow halo-like highlight. The thin cavity wall is seen in its entirety.

FIG. 3. (Center left) Case 1. January 8, 1943. The upper half of empty cavity seen in the right apex. Slight residue of iodized oil and infiltration in right upper lobe.

FIG. 4. (Center right) Case 1. February 2, 1943. Right, lordotic, apical. The round thin-walled empty cavity is seen in its entirety.

FIG. 5. (Lower left) Case 1. March 6, 1943. Cavity in right upper lobe filled with iodized oil.

FIG. 6. (Lower right) Case 2. May 30, 1943. Large cavity in right upper lobe, two-thirds filled with a homogeneous dense mass.

FIGS. 1–6

The temperature fell by lysis and became normal in nine days on August 23, 1942. The pulse and respiration showed a concomitant drop to normal. Two days after the acute onset the sputum was blood-tinged but this cleared within twenty-four hours. The pain in the right upper chest, which was aggravated by cough, stopped after three days. The expectoration and cough gradually decreased and after nine days was only slight and the sputum was no longer foul.

An X-ray film of August 29, 1942 showed slight resolution of the previously described new infiltration. The patient's condition remained unchanged and he was afebrile until September 6, 1942 when the temperature rose to 100°F. The fever slowly increased to 102.6° F. by September 14. There was no change in symptoms until this date when he raised about two drams of bright red blood. The sputum was dark bloody for two days and thereafter it was clear. The temperature fell by lysis, became normal on September 18, 1942 and remained so for the rest of the hospitalization period.

Resolution in the first and second right anterior interspaces was slow and progressive. The patient continued well except for slight cough and scant expectoration. By January 8, 1943 the roentgen examination (figure 3) showed marked resolution of the infiltration in the right upper lobe, with residual coalescent linear and mottled areas, and iodized oil in the second interspace and a few small nodules in the first interspace. The upper half of the bronchiectatic cavity was visible in the right apex above the clavicle and it was apparently empty.

To better delineate the entire cavity, a lordotic apical view (figure 4) was taken and this showed a round, thin-walled cavity between the first and second anterior ribs measuring 3.5 by 3.0 cm. with several linear fibrotic lines radiating from the wall, especially in the superior and lateral aspects. The cavity was empty.

Additional sputum cultures showed *Staphylococcus albus* and Gram-negative not identified diphtheroids. No anaerobes or fungi were isolated. All examinations (sputum concentrations, gastric contents, sputum and gastric cultures and a guinea pig inoculation) for tubercle bacilli were negative.

Iodized oil was instilled into the right upper lobe bronchus on March 6, 1943 and, in a horizontal supine position the oil filled the cavity (figure 5). The remainder of the bronchial tree showed no significant degree of dilatation. As soon as the patient was placed in an erect position, the contrast medium was rapidly evacuated from the cavity.

The patient was discharged March 18, 1943 to be admitted to Bellevue Hospital for a lobectomy. The operation was performed by Dr. Charles W. Lester. The author wishes to express sincere thanks to Doctor Lester for the information about the patient's stay there.

At Bellevue Hospital, the sputum cultures showed *Staphylococcus albus*, *Staphylococcus aureus haemolyticus*, and gamma-*Streptococci*. No acid-fast bacilli were found. Bronchoscopy revealed some reddening and purulent exudate in the right upper lobe bronchial orifice which had a definite foul odor. There was no evidence of a tumor or ulceration.

The operation was performed on May 28, 1943 and the right upper and part of the right middle lobe were removed. The remainder of the middle lobe, which was about two-thirds, was sutured over the stump and it was found that the middle lobe could then be inflated.

The resected material was examined by Dr. D. Spain. "The upper and middle lobes are not separable and there is one opening at the fissure between the outside of the lung and inner cavity. The medial surface of the upper lobe is shredded and loose dilated ends of bronchi are studded over its surface. On sectioning the lung, a large multiloculated

cavity in the apex is opened. There is another smaller but similar cavity in the middle of the lobe. There are a few firm, small, gray nodules. The middle lobe is noncrepitant. The bronchi do not appear dilated.

"Microscopic examination: Sections through various parts of the right upper and right middle lobes reveal the bronchi to be dilated and lined by columnar epithelium. In places the lining is several layers thick, the walls are infiltrated with lymphocytes and plasma cells and there is a good deal of fibrosis. This same lining extends directly into the saccular dilatation leading from the bronchi. Numerous infoldings are seen in the bronchi. The parenchyma shows considerable fibrosis and focal and diffuse accumulations of lymphocytes. The pleura shows some fibrosis. Diagnosis: (Dr. W. C. Von Glahn) Infected bronchiectasis; fibrosis of lung and pleura."

The patient was discharged from Bellevue on November 5, 1943. An X-ray film at that time showed a clear left lung with complete expansion of the right lower lobe with a thickened pleura at the periphery. His condition has remained good and he has been on full activity since his discharge.

Case 2: This case was very kindly contributed by Dr. Milton S. Lloyd. The author wishes to express deep appreciation and gratitude to Doctor Lloyd for the information about this patient.

The patient, *T. B.*, a thirty-seven old, white male, British sailor, was employed in the British Merchant Marine. His illness began with haemoptyses in June, 1940. During May, 1943 haemoptyses became severe and because of great blood loss he required hospitalization in the Gorgas Hospital, Panama Canal Zone. X-ray examination at that time (figure 6) revealed a large pear-shaped, moderately thick-walled cavity in the right upper lobe, extending from the level of the third to the fifth posterior interspaces. The inferior two-thirds of the cavity were filled with a homogeneously dense, smooth-edged mass. This simulates the pathognomonic roentgen sign of echinococcus cyst. Supportive treatment was rendered and the patient was discharged August 4 and placed aboard a merchant ship for return to England. However, severe haemoptyses made it inadvisable to carry him further than New York City. He was put ashore August 19, 1943 and admitted to St. Vincent's Hospital, Staten Island.

A bronchoscopy was done by Dr. M. S. Lloyd. A smear from the right upper lobe was negative for tubercle bacilli. Iodized oil was instilled and it entered the cavity and filled it and surrounded the solid density within. The cavity in the right upper lobe was considered to be cystic or bronchiectatic and a lobectomy was recommended. The patient was transferred to the French Hospital in New York City on September 5 and there the right upper lobe was removed by Dr. M. S. Lloyd on September 8.

Pathological examination by Dr. Cyril Solomon showed the cavity in the right upper lobe to be bronchiectatic and the solid round mass within it, a ball of inspissated blood clot, containing much oxidized iron. This solid mass formed a check valve. Microscopical examination of the inspissated clot showed serial laminations of blood cells.

Recovery of the patient was uneventful and reëxpansion of the remaining lobes after the operation was slow but steady.

COMMENT

The X-ray appearance of a homogeneous round mass enclosed by a crescentic air space has been considered pathognomonic of an echinococcus lung cyst, but it also occurs in pulmonary lesions of other aetiology when round densities are pres-

ent within cavities. Echinococcus cysts grow rapidly and are usually much larger than these pulmonary cavities with densities and the pericystic air space may be narrow and not persist for long. The differential diagnosis of these conditions will depend on additional clinical and laboratory data and may be quite readily made. But the fact remains that the roentgenological sign, which has been considered pathognomonic of pulmonary echinococcosis, can be simulated by other lesions. This has some practical importance for echinococcus disease is prevalent in South America, Iceland, Australia, New Zealand and North Africa, and it is not uncommon in Central Europe. This disease no doubt will be diagnosed more often in this country when many thousands of members of the Armed Forces return from these lands.

The typical shadow of a round mass and crescentic air space is due in an echinococcus lung cyst to air that has entered, through the bronchi, the space between the entire echinococcus vesicle or parasite and the lung. The outer membrane around the air space is not part of the cyst but is the compressed lung tissue ("the adventitia") which has been formed by the pressure of the growing echinococcus mass. In the other lesions with intracavitary densities the air space is within an actual pulmonary cavity and the cavity is partly filled by a dense mass.

Intracavitary densities are interesting lesions. This unusual X-ray picture of a uniform round density within a cavity has not often been seen and it has not been readily or easily interpreted. We have presented two bronchiectatic cavities with densities caused in one instance by a mass of inspissated pus and in the other by a blood clot.

There are many lesions that might present this type of shadow, for under proper conditions a mass or density could form within any pulmonary cavity. Its rare occurrence in spite of the commonness of pulmonary cavitation is due to the infrequency with which all the causative factors are operative. It would be necessary first to have some obstruction in the bronchial drainage. Without this there would be no retention of the cavity contents. (The factor of bronchial obstruction is indicated by the fact that both of our cases were bronchiectatic cavities.) Impaired drainage must be combined with an accumulation of a sufficient amount of material. A diminution in the absorption of the substances within the cavity would help this process. Viscid or coagulated material would have less chance of evacuation from a cavity.

The intracavitary densities have the shape of the cavity wall. This would indicate that they have been in close apposition to the wall of the cavity or that they have filled the vomica completely. (At one time there may have been complete bronchial obstruction.) The cavity contents form a solid homogeneous mass by hardening or inspissation. The dry mass can then more easily separate from the cavity wall. This separation must be associated with patency in the draining bronchi so that air can enter the cavity. On the other hand, the intracavitary mass may form and may be free in the cavity at all times, or the mass may itself cause a check-valve mechanism.

The formation of the intracavitary densities in our two cases is explained in the following manner:

In case 1 a cavity was present that contained pus. Impaired bronchial drainage must have existed that prevented the pus from being evacuated. The cavity therefore became partially or completely filled with pus that remained *in situ* for a long time. Under these circumstances it became thickened and inspissated and became a solid mass. It is not uncommon in chronic suppuration to have pus inspissated and cheese-like in consistency. The existence of bronchial obstruction would explain why the cavity could not be filled with iodized oil at the first attempt; the inspissated mass may have acted as a check valve. Though the inspissated focus remained stationary for a long time, modifications occurred rapidly. Eleven days after an X-ray film had revealed no changes, liquefaction of the inspissated mass occurred. Although the liquefied material would of itself be evacuated easily, it is probable that some alteration to improve bronchial drainage took place, for the cavity rapidly and completely became empty. This would also explain the ease with which the empty cavity filled with iodized oil.

Bleeding into cavities will not infrequently cause blood clots to appear. These, however, are expectorated or absorbed or "change in size, shape, contour, and position, and disappear under observation" (3). The inspissation of a blood clot to form a persistent round solid focus, as in case 2, is uncommon. The accumulation of blood in this cavity must apparently have been associated with impaired drainage. There was, however, no complete obstruction as varying amounts of blood were expectorated. A large blood clot was formed and, with additional periods of bleeding, new layers of thrombus material were deposited forming a laminated clot. The gradual enlargement of the blood clot was helped by the fact that it acted as a check valve that prevented complete cavity drainage. The clot gradually dried and hardened.

SUMMARY

Two cases have been presented with the interesting and unusual roentgenological picture of a homogeneous large density within a bronchiectatic cavity. The intracavitary densities resulted in one instance from a mass of inspissated pus, and in the other, from a blood clot. The formation of these densities has been discussed. In both cases lobectomies were performed. The appearance of a round mass surrounded by a crescentic air space has been considered pathognomonic of an echinococcus cyst in the lung. However, this roentgenological sign is not pathognomonic of echinococcus disease because it is simulated by other pulmonary lesions of various aetiology when round densities are present within cavities.

SUMARIO

Preséntanse dos casos con el interesante y extraño cuadro roentgenológico de una gran sombra homogénea en una caverna bronquiectática. Las sombras intracavitarias procedían en un caso de pus espesado y en otra de un coágulo

sanguíneo. Discútese la formación de esas sombras. En ambos casos se ejecutaron lobectomías. La aparición de una masa redonda rodeada de una cámara aérea en forma de media luna ha sido considerada patognómica de quiste hidático del pulmón, pero no es así, dado que simulan ese signo roentgenográfico otras lesiones pulmonares de variada etiología que presentan sombras redondas situadas en cavernas.

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TUBERCULOSIS OF THE ANTRUM[1]

Report of a Case

DAVID B. RADNER AND FORREST J. PINKERTON

Tuberculosis of the antrum is sufficiently rare to warrant the report of a single case. During recent years Denoyer (1) and Trenis (2) have brought attention to tuberculous foci in the oropharynx. While chronic suppuration of the paranasal sinuses is frequently encountered, tuberculosis of the nasal accessory sinuses is rarely diagnosed. Invasion of the sinuses secondary to nasal tuberculosis is discussed by Lederer (3) and apparently is more common than primary involvement of the sinuses. Fallas (4) believes that the sinuses become involved either by the haematogenous route or by extension from infection originating in the eye, the nose or the teeth. Continuity from the teeth appears to be the commonest mechanism. In 1938 Hersh (5) reviewed the literature, collecting 26 case reports of tuberculosis of the sinuses. In the case reported by Hersh the presence of a tuberculous lesion in the lumbar spine substantiated the belief that the sinus involvement resulted from haematogenous dissemination. No mention was made of the presence of tuberculosis in the lungs.

The present report is of a case of antral infection whose specific nature might have been overlooked had it not been for bacteriological and histological study. As such it is of interest to the otorhinolaryngologist. To the phthisiologist it is significant because it might offer one possible explanation of the occasional patient with a roentgenographically normal chest with sputum positive for tubercle bacilli.

CASE REPORT

The patient, a Japanese male, was admitted to the Sanatorium on September 24, 1934 at the age of twenty. Admission was advised because of haemoptysis (4 ounces) one month previously. This had been followed by a second haemoptysis (4 ounces) one week later. Coincident with the haemoptyses the patient had noted fever, malaise and weight loss (5 lbs.). The sputum was blood tinged on admission, the temperature 99.2°F., weight 115 lbs. Physical examination was negative except for a few coarse, moist râles heard over the right apex and base. The roentgenogram of the chest revealed a minimal infiltration occupying the right apex and first interspace. Routine examination disclosed that the tonsils were moderately enlarged; that there was polypoid degeneration of both middle turbinates and that the larynx and ears were normal. The blood count was within normal limits. The polypoid changes progressed until April 12, 1935 when it was necessary to remove the mass on the left side under local anaesthesia. An uneventful recovery followed the operation and the nasal mucosa resumed normal appearance.

After an initial period of observation, disclosing the presence of acid-fast bacilli in the sputum, a diagnosis of minimal pulmonary tuberculosis was made. Due to clearing of the lesion after one month of bed-rest, it was decided to delay collapse therapy and continue the rest regimen. Serial roentgenograms revealed progressive clearing and the sputum was converted so that early in 1936 the patient was considered

[1] From the Leahi Hospital, Honolulu, Hawaii.

for discharge. This was postponed because a series of sputum specimens was positive on culture though negative on smear. Collapse therapy was reconsidered and on July 20, 1936 the right phrenic nerve was crushed.

On January 19, 1937 the patient complained of headache and pain in the left side of the face. The temperature was normal and physical examination revealed swelling of the left side of the face with some localized tenderness over the left antrum. The blood count on January 21, 1937 was again normal. The following day, January 22, 1937, the left antrum was irrigated with physiological saline solution and the solution returned clear. The solution was not studied bacteriologically after irrigation. Roentgen studies of the sinuses were made and revealed moderate thickening of the antral mucosa. Both antra appeared diffusely cloudy without evidence of definite polyp formation; the other sinuses were entirely normal. A tentative diagnosis of trifacial neuralgia was made and the patient was treated symptomatically.

The sputum remained intermittently positive and early in 1937 right artificial penumothorax was attempted but no free pleural space was found. Therefore, on February 13, 1937, after return of normal motion of the right leaf of the diaphragm, the right phrenic nerve was again paralyzed. When this failed to affect the intermittently positive sputum, bronchoscopy was advised but permission was refused by the patient until July 29, 1938 when examination failed to reveal any tracheobronchial disease. A smear taken from the right main bronchus contained acid-fast organisms but culture of this material remained negative.

In 1939 another unsuccessful attempt was made to induce artificial pneumothorax on the right side. While the sputum continued to be intermittently positive during 1939, there were fewer negative smears obtained as 1940 was reached. Apical, oblique and lateral films and various fluoroscopic examinations failed to disclose any lesion in the lung. The old apical lesion on the right had almost completely cleared in the interim and in April, 1940 nasopharyngoscopy and bronchoscopy failed to show any specific focus. A specimen taken from each main bronchus at this time was negative on culture for acid-fast organisms. Roentgen and lipiodol studies of the maxillary sinuses were repeated at this time. There was marked thickening of the mucosa of both antra, more of the left than the right, with very little air space in either. The sphenoid sinuses presented definite thickening of the mucosa and the left anterior and posterior ethmoids were slightly cloudy. The frontal sinuses were normal.

Reconsideration of the case in 1941 once more led the search to the sinuses and on August 6, 1941 a bilateral antrum wash was done, the washings from each antrum being sent to the laboratory for study; in both acid-fast bacilli were found on smears and confirmed by culture. This was repeated on September 4, 1941 when a positive on culture was obtained only from the left antrum. On October 10, 1941 a bilateral naso-antral resection was done. Operative report: "Both lateral nasal walls were more sclerotic than normal. White creamy pus was found in the left with more thickening of the mucosa than on the right. Bilateral naso-antral resection was completed with recovery of some hyperplastic tissue from each antrum for laboratory study."

At the time of surgery the washings from each antrum were cultured and inoculated into guinea pigs. Sections of the mucous membrane from each antrum were also used to inoculate guinea pigs. Positive animal inoculation was obtained with the tissue from the right antrum. Washings from the right antrum were negative both on culture and animal inoculation. Both the washings and the tissue from the left antrum were positive on culture and animal inoculation. Microscopical study of the tissue from the right side revealed fibrosis and chronic inflammatory reaction with no specific evidence of tuberculosis in the sections studied. The tissue from the left side revealed a fibrotic type of tubercu-

losis with well defined granulomata and giant cells. Postoperatively the patient was seen at regular and frequent intervals at the nose and throat clinic at which time the antra were irrigated and rarely did we recover pus or debris from the washings. The naso-antral windows had apparently allowed sufficient drainage to bring about healing. Following his dismissal from the hospital the patient was seen at frequent intervals at the office. Nasal discharge was never noted, but each time the antra were irrigated with sterile saline solution; the washings on cultures revealed no acid-fast organisms.

Throughout the hospital stay of the patient, his temperature remained normal with only an occasional rise to 99° or 99.2°F. The weight, which was 115 lbs. on admission, varied between 122 and 128 lbs. during the last three years. There were no symptoms referrable to the chest during this time. The clinical condition remained good throughout the course.

On January 29, 1942 the patient was seen again because of a profuse serosanguineous discharge from the left ear which followed an acute nasopharyngitis of several days' duration. In addition, he complained of nasal discharge, blocking of the nares, headache, tinnitis and reduced hearing. Under conservative treatment, the acute symptoms subsided by February 20, 1942, but mild nasal blocking and a small amount of thin, milky discharge remained until early in March, 1942 when he sustained a fracture of the nose. The fracture was well reduced but was followed by continuous blocking of the nose, serosanguineous discharge and increased discharge from the left ear. The swelling of the inferior turbinates was reduced and the aural discharge had almost ceased by June, 1942. X-ray studies showed a generalized clouding of all the sinuses, the antra being quite dense. On July 30, 1942 his left ear was healed and dry, his nose open and free of discharge. Since that date the nose and ear have remained healed and dry. Examinations of antral washings and sputa continue negative for acid-fast organisms.

From the X-ray studies and our clinical observations over a period of years, it is very likely that this patient will have a reactivation of his nasal symptoms due to the tuberculous infection. Although no acid-fast organisms were recovered, it is our opinion that his left ear is infected with tuberculosis.

SUMMARY

A patient is reported in whom, as a complication of minimal pulmonary tuberculosis, tuberculosis of the antra was diagnosed by bacteriological and histological examination.

SUMARIO

Descríbese un caso en el que, como complicación de una tuberculosis pulmonar mínima, se diagnosticó tuberculosis de los antros por el examen bacteriológico e histológico.

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THE FATE OF VERY YOUNG CHILDREN WITH TUBERCULOSIS[1]

GERTRUDE F. MITCHELL[2] AND HENRY STUART WILLIS[1]

Tuberculosis still presents a great number of unanswered questions, but on one fact there is universal agreement, namely, that the disease causes many deaths among the very young. Data on the issue vary. For instance it was formerly taught that all children under the age of two who became infected with the tubercle bacillus died of tuberculosis (Hutinel, 1912, and others). This has been contradicted many times, but as late as 1936 Nobecourt gave the following data from a study of 100 children: among those who developed tuberculin sensitiveness under three months of age, all died of tuberculosis; of those who developed it from three to seven months of age, 70 per cent died of tuberculosis; of those who developed it from seven to eighteen months of age, 51 per cent died of tuberculosis; of those who developed it from eighteen to twenty-four months of age, 30 per cent died of tuberculosis.

To accept the fact that the very young tolerate tuberculosis poorly, one needs only to read of Blacklock's pathological experience or the clinical story as given by Price, Asserson, Brailey, Rosenberg, Kereszturi and Lincoln, among many. Others in the field have reported fatality rates much lower than those quoted and have pointed to numerous factors besides age as contributory to death from this disease. Many have emphasized intimacy of contact as an element of first importance, pointing out that the infant has few contacts with the outside world but that those few are frequent and oft-repeated. The death rate is reported as being more than twice as high in children whose mother rather than those whose father was the source of infection (LeFebure). Duration of the interval between break of contact and development of disease, the general health, hygienic and dietary regimen under which the child lives are also obvious factors.

By 1930 it was well recognized that considerable numbers of very young children develop clinical tuberculosis without fatal results. An extensive paper could be devoted solely to the literature on these issues. However, several excellent studies have appeared during the last decade, each with a very useful bibliography.

It is obvious that numerous elements contribute to the lack of uniformity in conclusions drawn from studies on this question. Among these are such factors as: (*1*) basis of the diagnosis, that is, whether mere tuberculin sensitiveness, clinical disease, physical signs or X-ray signs were depended upon or whether all were used; (*2*) existence of adequate hospital facilities and use of these; (*3*) race and economic status of the group of children under survey.

The Maybury Sanatorium offers favorable circumstances for treatment and study of children with tuberculosis because of its always adequate bed capacity and its ability to admit at once all cases of tuberculosis, with or without symp-

[1] Wm. H. Maybury Sanatorium (Detroit Department of Health Tuberculosis Sanatorium), Northville, Michigan.

[2] Detroit, Michigan. Formerly Resident Physician at Wm. H. Maybury Sanatorium.

toms, and to keep such patients, not for a limited number of weeks or months, but until the disease appears to be under satisfactory control or until death supervenes. From its opening in 1922 until late 1938 when the present study ended, 2,091 patients up to age fourteen were admitted to the Children's Division of the institution. The admissions represented all types of tuberculous disease. Out of this large group of cases there were 243 who were three years of age or younger, whose record of hospitalization, discharge and follow-up constitute the basis of this report.[3] Some of the patients were brought to the hospital because of manifest illness but the larger number were diagnosed in the course of contact examinations and most of the latter were without symptoms. In keeping with general experience, many of these children failed to yield significant signs on physical examination. Yet they were all given physical as well as X-ray and laboratory examinations. This was done in the thought that a diagnosis should be supported by as much, rather than as little evidence as could be obtained.

All of the 243 had tuberculosis. None was admitted on the basis of a tubercu-

TABLE 1

Distribution of cases according to admission classification and color

ADMISSION CLASSIFICATION (X-RAY DIAGNOSIS)	WHITE	NEGRO	TOTAL
Primary			
1. Disease involved tracheobronchial lymph nodes only	44	13	57
2. Parenchymal tissue only	29	17	46
3. Tracheobronchial nodes and parenchymal involvement	63	47	110
Reinfection	17	13	30
Total	153	90	243

lin reaction alone. They were classified on the basis of the X-ray appearance into primary and reinfection types.

Unfortunately, in many cases the terms primary and reinfection do not admit of sharp definition, except in a broad and sometimes a theoretical way. In this instance conventional criteria have been used. The basis of differentiation has centered around demonstrable enlargement of the tracheobronchial lymph nodes and the presence of calcium deposits. Cases having enlargement of these nodes, with or without signs of disease in the lung, were listed as primary (figures 1 and 2). So also were certain cases having characteristic pulmonary shadows but without demonstrable lymph node enlargement and with few or no symptoms (figure 4). In many of the latter the regional lymph nodes enlarged subsequently. Cases with pulmonary disease and calcium deposits in the pulmonary fields or at the root were called reinfection (figure 8).

[3] The follow-up records of these children were made possible through the kindness and efficiency of the staff in the Out-Patient Department at Herman Kiefer Hospital, Dr. Arthur P. Derby, Director.

Data concerning the types of tuberculosis presented by these children are indicated in table 1. From this it will be seen that both primary and reinfection types were represented, that approximately three-fifths of the children were white and that about twice as many had disease in the lungs and tracheobronchial lymph nodes together as had involvement of either of these tissues alone. The reinfection cases numbered only 30.

What happened to these children? As mentioned previously a significant fact in respect to them is this: the children were put in the hospital and hospitalization was continued for as long as it was needed. One child remained in the hospital for sixty-two months. Fifty-eight per cent of these children were hospitalized one year or longer. Reference to table 2 will indicate that the experience in this group of children ran true to the expected, namely, that the outlook for the reinfection disease in both races was distinctly worse than for the primary lesions.

TABLE 2

Distribution of cases according to admission classification, color and condition at discharge

ADMISSION CLASSIFICATION	WHITE			NEGRO		
	Cases	Deaths		Cases	Deaths	
		Number	Per cent		Number	Per cent
Primary	136	8	5.9	77	11	14.3
Reinfection	17	8	47.1	13	10	76.9
Total	153	16	10.5	90	21	23.3

Altogether 18 of 30 cases with reinfection tuberculosis died while in the hospital; this is 60 per cent of the group.

Table 2 points out also that, for both primary and reinfection cases, the Negro fared far worse than the white child. Of 153 white children 16, or 10.5 per cent, died in the hospital as compared to 21, or 23.3 per cent, of the 90 Negro children. The fatality rate for the Negro was thus more than twice that for the white children.

In regard to the duration of hospitalization, these children were arbitrarily put into two groups: (*1*) in hospital three months or less and (*2*) in hospital longer than three months. (The average stay was quite long, being over a year in the majority of cases.) As shown in table 3, 46 fell into the first group and 197 in the other. Many of those in the first group were seriously ill and died. Twenty-seven of the 46 died, mostly within a few days of admission. Several were moribund upon arrival. Of these 27 deaths, miliary disease and meningitis accounted for 19; pulmonary tuberculosis and tuberculous enteritis caused death in 5; nontuberculous disease took 2; one died of unrecorded cause.

This table does not show detailed analysis of the facts, but it turned out that 29 white children were included in the first or short hospitalization group; of these, 12 died. There were 17 Negro children in the group, of whom 15 died.

After the early critical period passed, the fatality rate lessened markedly for, in the group with longer stay in the Sanatorium, only 10 of 197 died. The rate was thus many times greater in the shorter than in the longer period of hospitalization. Six of the 10 deaths in this latter group were due to tuberculosis; 2 to nontuberculous diesase and 2 had no recorded cause. In the group with longer hospital stay, 4 deaths occurred among 124 white and 6 deaths among 73 Negro children.

In itself this may not indicate any particular advantage of hospitalization because most of the deaths among the 46 that were in the hospital only a brief time occurred very soon after admission. It does point out, however, that, once a tuberculous patient is in the hospital, these malignant complications and indeed any menacing spread of the disease occur relatively infrequently, as witnessed

TABLE 3

Distribution of cases according to length of stay in hospital and condition at discharge

LENGTH OF STAY IN HOSPITAL	CASES	DEATHS	
		Number	Per cent
Three months or less	46	27	58.6
More than three months	197	10	5.1
Total	243	37	15.2

TABLE 4

Distribution of cases according to age at admission and condition at discharge

AGE AT ADMISSION	CASES	DEATHS	
		Number	Per cent
0 to 19 months	62	18	29.0
19 to 36 months	181	19	10.5
Total	243	37	15.2

by only 10 deaths in 197 cases in the group that was in the Sanatorium a longer time.

This feature is illustrated in table 6 which indicates that deaths from tuberculosis after discharge were few and that there is relative security following adequate hospitalization.

It is well known that age is an important contributing factor in death from tuberculosis. Data bearing on this fact are presented in table 4 which gives the number of cases and deaths in these children when divided into two groups: one from birth to and including eighteen months and one from nineteen to thirty-six months. Here again the younger children experienced the greater fatality. Of 62 children less than nineteen months of age, 18, or 29.0 per cent died. There were 181 in the group nineteen to thirty-six months, of whom 19 died. This

gives a percentage of 10.5 which is practically one-third the rate of the younger group.

The clinical status at discharge when considered in relation to classification on admission is presented in table 5 which indicates that a large proportion of all the children were discharged as apparently arrested. The term apparently arrested is used in a very conservative way. By the time the child was ready for discharge he had gone through a long period of bed-rest, followed by graduated exercise and play and was thought to be ready to resume normal life. For practical purposes he was well when this classification was applied. In an occasional patient the hospital stay was featured by some collapse procedure.

Table 5 points out that 206 children were discharged alive. Of these, 194 had primary and 12 reinfection tuberculosis. Of 57 cases who had primary tuberculosis with disease limited to the tracheobronchial lymph nodes, 43, or

TABLE 5

Distribution of cases according to admission classification and clinical status on discharge

ADMISSION CLASSIFICATION	CLINICAL STATUS ON DISCHARGE						
	Apparently arrested	Quiescent	Improved	Unimproved	Undetermined*	Dead	Total
Primary							
Tracheobronchial lymph nodes only	43	3	4	1	3	3	57
Parenchymal tissue only	31	4	4	1	1	5	46
Tracheobronchial nodes and parenchymal involvement	80	8	10	1	0	11	110
Reinfection	9	0	2	1	0	18	30
Total	163	15	20	4	4	37	243

* Stay too short to determine classification.

75.4 per cent, left the hospital as apparently arrested. Of 46 with disease involving the lungs only, 31, or 67.4 per cent, were apparently arrested at discharge. Of 110 admitted with disease in both lungs and bronchial lymph nodes, 80, or 72.8 per cent, were apparently arrested upon leaving the hospital. Of all 213 cases of primary disease, the discharge classification was apparently arrested in 154, or 72.2 per cent, and discharge was by death in 19, or 8.9 per cent. Of 30 reinfection cases, 12, or 40 per cent, recovered and 18, or 60 per cent, died. When discharge condition is considered for all, it is obvious from this table that 163 (67.0 per cent) did well and 37 (15.2 per cent) died. This figure of 163 is 79 per cent of all cases discharged alive.

Table 5 points out another fact. The children who had parenchymal disease (reinfection cases included) numbered 186. Of these, 34, or 18.2 per cent, died. This fatality experience may be compared with that quoted by Brailey (1) for a group of out-patient children. The Maybury figures represent deaths occurring during hospitalization (which averaged about one year) and Brailey's represent

one year's observation. The deaths among the latter's children were 31.3 per cent for the first year after contact with the dispensary.

It has already been pointed out that duration of stay in the hospital appeared to be an important factor in the fatality rate in these children during their residence in the institution. The postdischarge fatality experience is also significant and is shown in table 6. Although the number of deaths is small, the patients who remained in the hospital longer fared better; in fact they fared four times as well as those in the shorter hospitalization group. The total known deaths after discharge among 160 followed patients were only 10. Three of these occurred among 15 followed patients in the short hospitalization group and 7 among 145 in the group with longer stay in the hospital. Of the 3 deaths in the first group, one was caused by tuberculosis, one by nontuberculous disease (mastoiditis) and one by an unknown cause. Of the 7 deaths in the second or longer hospitalization group, 2 were from tuberculosis, 2 from nontuberculous disease and 3 from unknown cause.

TABLE 6

Distribution of all cases discharged alive as to length of stay in hospital and condition at end of follow-up

LENGTH OF STAY IN HOSPITAL	ALIVE	NOT FOLLOWED	TOTAL FOLLOWED	DEATHS AMONG THE FOLLOWED	
				Number	Per cent
Three months or less....	19	4	15	3	20.0
More than 3 months.....	187	42	145	7	4.8
Total.....	206	46	160	10	6.3

The data presented in table 6 included the 12 patients with reinfection tuberculosis who were discharged alive. What happened to these cases during the follow-up period will be of interest. Nine of them left the Sanatorium as apparently arrested, 2 as improved, and one as unimproved. Five of the 12 were not followed and the others, in the main, were under observation for less than five years, but all were well when last seen. The small number of cases involved and the rather short observation period hardly justify definite conclusions as to the ultimate fate of children with reinfection disease.

Attention will now be focused on the discharged patients with primary tuberculosis alone, as shown in tables 7, 8 and 9.

These cases numbered 194 at discharge (table 7), but it was not possible to follow 41 of them. This leaves 153, of whom 10, or 6.5 per cent, died. Only 4 of the 126 followed cases who were discharged as apparently arrested (3.2 per cent) died, whereas 6 died out of 27 classified as other than apparently arrested when they left the hospital. This points again to the fact that stay in the hospital sufficiently long to render the patient clinically, bacteriologically and roentgenologically well pays good dividends.

The clinical status of the 41 unfollowed cases cannot, of course, be known. In

view of the known course of 153 followed cases, it may be presumed that the experience of the unfollowed cases has probably been no worse than that of the known group. And this statement is based on the fact that the discharge condition of the 41, widely distributed among the total group, was as follows: 28 apparently arrested, 5 quiescent, 5 improved, 2 unimproved and one worse.

TABLE 7

Distribution of cases with primary tuberculosis discharged alive as to clinical status at discharge and condition at end of follow-up

CLINICAL STATUS AT DISCHARGE	TOTAL DISCHARGED	NOT FOLLOWED	TOTAL FOLLOWED	DEATHS AMONG FOLLOWED	
				Number	Per cent
Apparently arrested.....	154	28	126	4	3.2
Others*.....	40	13	27	6	22.2
Total.....	194	41	153	10	6.5

* Includes all cases discharged as quiescent, improved, unimproved and undetermined.

TABLE 8

Distribution of patients with primary tuberculosis discharged alive as to clinical status on discharge and length of follow-up in years

CLINICAL STATUS AT DISCHARGE	NOT FOLLOWED	LENGTH OF FOLLOW-UP IN YEARS											
		Less than 1 yr.	1	2	3	4	5	6	7	8	9	10	Over 10	Total
Apparently arrested.....	28	3	7	14	15	9	14	25	13	11	8	3	4	154
Others.....	13	3	5	0	3	7	1	1	2	0	2	0	3	40
Total.....	41	6	12	14	18	16	15	26	15	11	10	3	7	194

TABLE 9

Distribution of the followed cases with primary tuberculosis according to clinical status on discharge and condition at the end of the follow-up

CLINICAL STATUS AT DISCHARGE	CONDITION AT LAST FOLLOW-UP			
	Well	Readmitted	Dead	Total
Apparently arrested.....	121	1	4	126
Others.....	21	0	6	27
Total.....	142	1	10	153

Follow-up contacts were made many times with some of these patients; only once with some; no such contact was possible with others. Follow-up extended naturally over a varying length of time, the longest being seventeen years. Duration of follow-up is presented in table 8 which shows the last contact only.

It is an interesting and significant fact in the apparently arrested cases that no death occurred among the 64 children who were followed six years or longer but that among 62 followed less than six years 4 deaths occurred.

The final condition at last follow-up of the 153 primary cases with whom continued contact was possible is interesting and is shown in table 9. One hundred twenty-one of 126 apparently arrested cases were well at last observation, as were 21 of 27 in other classifications. In other words, children treated adequately and kept sufficiently long in the hospital have an excellent chance of survival, irrespective of race and, not only of survival, but recovery.

REPRESENTATIVE CASES

Case 1. Primary tuberculosis, involving only tracheobronchial lymph nodes: M. S., a Negro boy fifteen months old; exposure to mother who cared for child until she was hospitalized two months before her death from tuberculosis. Child developed fever, cough, nasal discharge and "sore" eyes from four to eight weeks before hospitalization. X-ray film of the chest was clear two months before admission. Admission X-ray film (figure 1) showed extensive density above the root on the right side, suggesting enlarged tracheobronchial lymph nodes. Symptoms disappeared three or four weeks after admission. Cultures of stool were negative. Further course in the Sanatorium was uneventful (twenty months); then, extensive calcification appeared and a shadow remained indicating some persisting enlargement of lymph nodes.

Case 2. Primary tuberculosis with disease in tracheobronchial lymph nodes predominant: R. W., a Negro boy, age three years, exposed to tuberculous mother. Four to six weeks before admission patient developed sore throat, fever, anorexia and vomiting, followed soon by cough, lassitude and loss of weight. An X-ray film, figure 2, showed great enlargement of two lymph nodes on the left and slight parenchymal clouding in the second interspace. Shortly after admission wheezing appeared over the lower portion of the left upper lobe; this persisted intermittently for about four months and extension of parenchymal lesion occurred. Bronchoscopic examination at that time revealed marked bulging along the medial wall and marked reduction in size of the left main bronchus, apparently due to external pressure by enlarged tracheobronchial lymph nodes. His two and a half year course in the hospital was uneventful. An X-ray film at the time of discharge showed gradual absorption of the parenchymal lesion and shrinking of the enlarged lymph nodes with marked calcium deposits, as illustrated in figure 3. Gastric washings were negative once and positive once on culture, and culture of stool was negative.

Case 3. Primary tuberculosis with parenchymal involvement only: R. N., a Negro boy two years ten months old, without known contact. Nasal discharge led to admission to Children's Hospital where patient was found to have fever from 101° to 103°F. This and consolidation of a large area in the upper two-thirds of the left lung led to diagnosis of pneumonia for which sulfadiazine was given without effect. Diagnosis of tuberculosis caused admission to Maybury Sanatorium one month after onset of symptoms. For the first two weeks in the Sanatorium his temperature remained high, cough was severe, abdomen was distended and tympanitic and bowels moved four or five times a day. Stools were mushy and foul. Gastro-intestinal series was normal. Admission film (figure 4) suggested atelectasis. Two efforts at bronchoscopic examination were

FIG. 1

FIG. 2

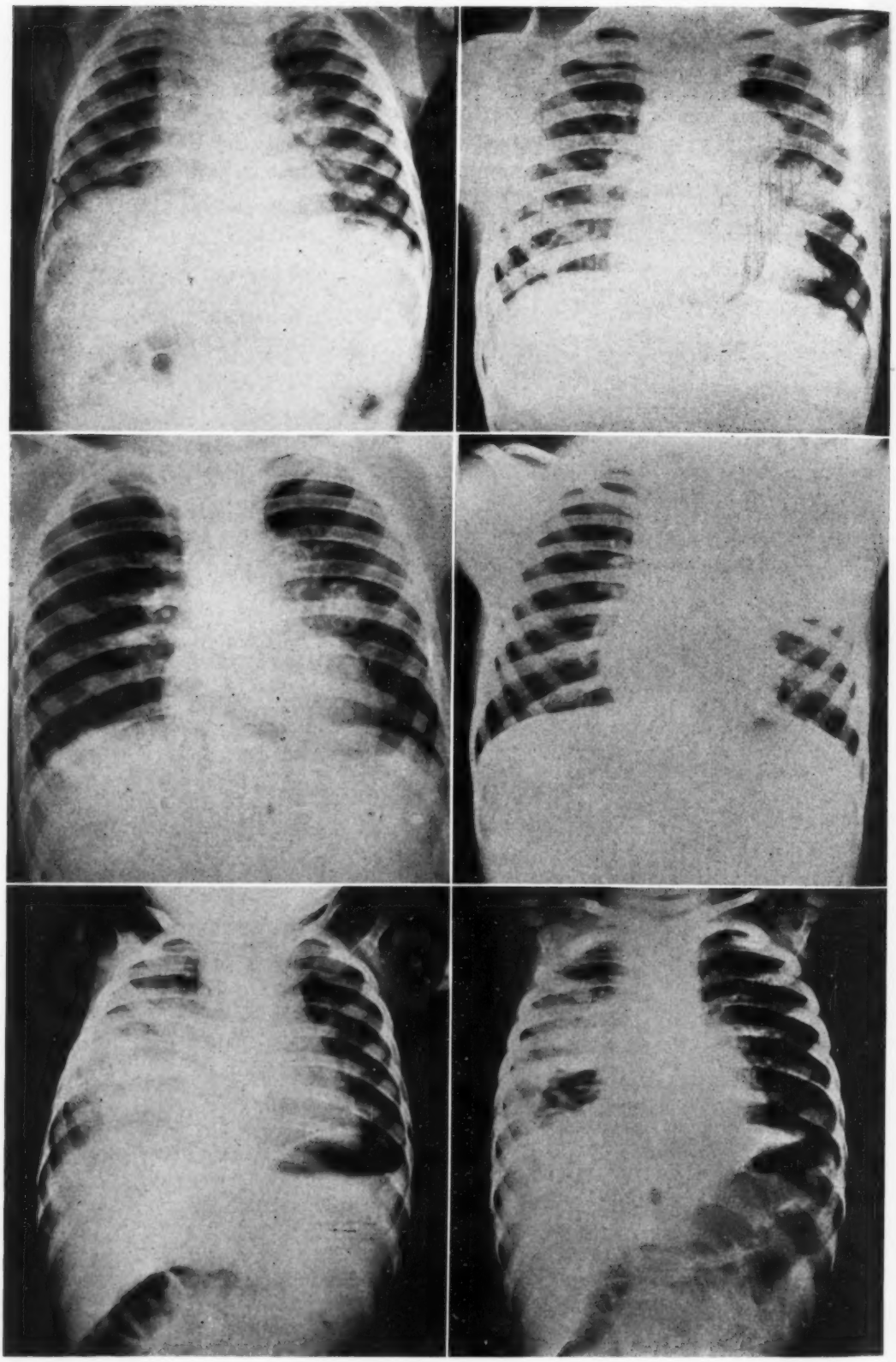


FIG. 3

FIG. 5

FIG. 6

unsuccessful. Culture of gastric washings and oesophageal secretions examined two months apart yielded tubercle bacilli. Shortly after admission improvement set in and lesion cleared.

Case 4. Primary tuberculosis involving both pulmonary tissue and tracheobronchial lymph nodes: S. P., a white boy ten months old. Exposure to mother. Coughed for about three months and failed to gain weight during the last few weeks prior to admission. Was thin, pale and weak. Admission temperature was 102°F. He had a large area of consolidation in the middle and basal portions of the right lung and increase in shadow at right root, as illustrated in figure 5. Culture of throat swab revealed tubercle bacilli on three occasions. He became dyspnoeic and cyanotic and lost weight; area of disease increased in extent. Large cavitation developed, as shown in figure 6, and the patient died three months after admission.

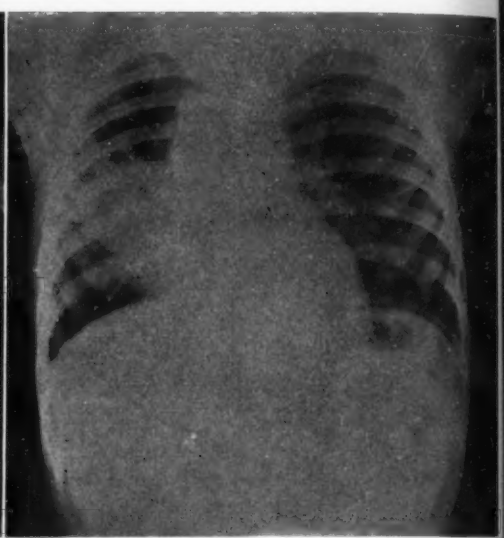
Case 5. Primary tuberculosis with pulmonary and lymph node involvement: R. L., a Negro girl seventeen months old, exposed to tuberculous mother from birth to sixteen months of age. Contact was broken when the mother was hospitalized in a moribund condition and died. The child had no symptoms and was diagnosed on contact examination. She had measles two weeks before admission. Her tuberculin reaction was positive. She was afebrile and asymptomatic on admission. One week later temperature rose to 104.8°F. and pulse to 150. Patient was pale, listless. An X-ray film showed soft lesions in the right lung in addition to those present when she entered. There was scattered parenchymal mottling throughout the upper half of the right lung with an area of consolidation in the apical region and considerable lymph node enlargement at the root. She developed tuberculous cervical adenitis with a sinus tract. Symptoms abated gradually, lesions became steadily smaller in X-ray films, except for one slight exacerbation one year following admission. Thereafter the course was without further incident. Adenitis healed with scar. The child was discharged as apparently arrested after two years and eight months in the hospital. Cultures of gastric specimens were positive on three of four occasions and of pus from cervical sinus tract. Final X-ray film revealed extensive calcification.

Case 6. Reinfection tuberculosis: J. D., a white boy two and a half years old. At sixteen months of age he became acutely ill with what was called pneumonia; he had high fever, cough, wheezing and anorexia and was sent to a general hospital. At that time X-ray examination revealed distinct lymph node enlargement at and above the root on the right but no parenchymal lesion and no calcium deposit (figure 7). Diagnosis was changed to primary tuberculosis. Patient returned home and was kept under the observation of a private physician. Acute symptoms subsided but cough and wheezing persisted. Fifteen months later (at the age of two and a half years) he became acutely ill with what was again thought to be pneumonia and was characterized by marked wheezing, high fever and moderate cough. He was in a hospital for two weeks. Tuberculin test, not done earlier, was now positive. X-ray film of the chest showed a large area of dense infiltration near the middle of the right lung and lymph node enlargement at and above the root on the right, the latter having considerable calcium in it (figure 8). With this lesion the child was admitted to Maybury Sanatorium. He was unusually small for his age and bronchoscopic examination seemed ill advised. On admission temperature was 101°F., pulse 145. He was pale, had nasal discharge and a slight wheeze which subsided after one day of steam inhalations. Four months after admission he had another short bout of

high fever but thereafter his course in the hospital was uneventful. The child grew normally well; pulmonary lesions absorbed gradually. Sixteen months later both pulmonary and lymph node lesions had receded markedly, as shown in figure 9. Remained well.

FIG. 7

FIG. 8



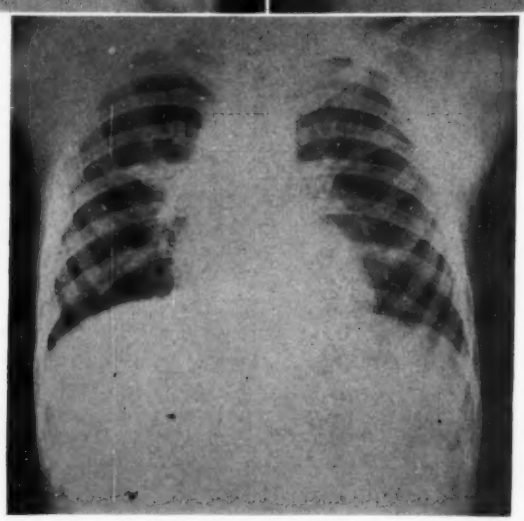


FIG. 9

Case 7. Reinfection tuberculosis: L. J., a Negro girl, fourteen months of age, exposed to tuberculous mother who died within a month of her hospitalization. About one month before admission the child showed considerable loss of weight and was indifferent to food. Tuberculin reaction was positive; she was anaemic (64 per cent haemoglobin). She

came in with extensive disease characterized by marked infiltration in the lower half of the left lung with a cavity 2.5 cm. in diameter. Except for upper respiratory infection on two occasions, measles and an attack of diarrhoea, her two years' course in the hospital was uneventful. Culture revealed tubercle bacilli in one of four stool specimens and in one of three specimens obtained by gastric lavage. She was classified as apparently arrested on discharge and was followed for two and a half years. She was well when last seen. This is an example of parenchymal disease, called reinfection type but in which the tracheobronchial lymph nodes showed enlargement secondary to pulmonary lesion.

DISCUSSION

The terms primary and reinfection tuberculosis are well established in nosology, yet in a considerable number of cases the differential diagnosis cannot be made. The typical case of primary disease is well recognized and characteristic as is the typical case of reinfection. But a good many cases of primary disease will develop and progress unremittingly or haltingly to death. Occasionally primary tuberculosis will clear in the usual way, only to lead to exacerbation that neither resembles nor behaves like reinfection disease which, by definition, it is; rather, it again runs the course of primary infection.

Furthermore, the pathologist finds it difficult to reconcile this concept of primary tuberculosis with what he sees in his experiments where all the phenomena of reinfection or allergy (exudation, inflammation, tuberculin reaction, etc.) develop a few short weeks after the bacillus is introduced into the body. He recognizes the primary complex as an entity, but this concept leaves a lot of questions to be answered in respect to prmary and reinfection disease. The issues on which these terms are based appear to need some degree of reassessment. Tuberculosis is a serious disease irrespective of the name by which it is called.

In some quarters it is contended that hospitalization of children with tuberculosis is unnecessary. Unfortunately for the circumstances we do not have a group of cases with disease comparable to those reported in this paper who were treated outside the hospital and whose experience could be compared with these. Such comparable groups are necessary for unequivocal deductions as to the advantage of hospitalization. Perhaps the most suitable group for comparison from the literature is that reported by Brailey (1) who studied children under out-patient clinic control. Of Brailey's cases which had parenchymal disease at first contact, 31.3 per cent died in the first year of observation, as compared to 18.3 per cent for Maybury's comparable group for the entire observation period of hospitalization and follow-up, or 22.7 per cent for the total period—with the unfollowed cases eliminated. The overall picture presented by the Maybury cases suggests that tuberculous children are benefited by hospitalization.

This study points to the probability that almost any large community presents an appreciable number of children with pulmonary tuberculosis. In such cases the lesions may be very extensive and may involve either the parenchymal tissue, the tracheobronchial lymph nodes or both. Whether classified as primary or reinfection tuberculosis, these children possess a serious threat to themselves and their contacts. For such children hospitalization seems indicated as a part of the community effort to meet effectively the issue of tuberculosis.

Children are biologically related to adults. Both contract tuberculosis and die from it, even though it is recognized readily that the prognosis in the typical primary case is better than in the average adult case. It seems only rational that careful hospitalization of any one, child or adult, with active tuberculosis is the course of wisdom.

CONCLUSIONS

1. The base material of this study comprises the hospitalization, discharge and follow-up experience of 243 children under the age of three who were admitted to a tuberculosis sanatorium. All of the children had tuberculosis. None was admitted merely because of his tuberculin reaction. Both primary and reinfection types were present. Of these children, 153 were white and 90 Negro.

2. In both white and Negro children, the outlook was distinctly worse for the reinfection than for the primary type of tuberculosis.

3. With both the primary and reinfection types of tuberculosis the Negro child had a definitely poorer chance of survival than the white child.

4. The younger children (birth through eighteen months) had a much higher fatality than the older ones (nineteen to thirty-six months).

5. The children discharged alive who had remained in the hospital longer than three months experienced a decidedly more favorable fatality experience than those who had remained a shorter period. (Fifty-eight per cent of all the children remained in the hospital longer than one year.)

6. The children discharged as apparently arrested had a more favorable subsequent fatality experience than those discharged with a less favorable clinical status.

7. Nearly all of the children admitted with active primary lesions who were hospitalized until they could be discharged as apparently arrested were found, over a rather long period of follow-up, to have remained well. For this reason a plea is made that children with active tuberculosis, with or without symptoms, be provided with adequate treatment in a hospital.

CONCLUSIONES

1. El material en que se basa este estudio comprende la hospitalización, alta y observación subsecuente de 243 niños de menos de tres años que fueron recibidos en un sanatorio para tuberculosis. Todos ellos padecían de la enfermedad y a ninguno se le recibió meramente debido a su reacción a la tuberculina. Se observaron los tipos tanto primario como de reinfección. De los niños 153 eran blancos y 90 negros.

2. En los niños tanto blancos como negros el pronóstico fué mucho peor para el tipo de reinfección que para el primario.

3. Tanto en el tipo primario como en el de reinfección de la tuberculosis, el niño negro tenía muchas menos probabilidades de sobrevivencia que el blanco.

4. Los niños más jóvenes (recién nacidos hasta los dieciocho meses) mostraron una letalidad mucho mayor que los mayores (diecinueve a treinta y esis meses).

5. Los niños dados de alta que habían permanecido en el hospital durante más de tres meses manifestaron una letalidad decididamente más baja que los que permanecieron menos tiempo. (Cincuenta y ocho por ciento de todos los niños permanecieron en el hospital más de un año.)

6. Los niños dados de alta con la enfermedad aparentemente estacionada mostraron una letalidad más baja después que los dados de alta en un estado clínico menos favorable.

7. Casi todos los niños recibidos con lesiones primarias activas que fueron hospitalizados hasta poder darles de alta como aparentemente estacionados, continuaron bien durante un período algo prolongado de observación subsecuente, por cuya razón abógase aquí porque se facilite tratamiento adecuado en el hospital a todo niño con tuberculosis activa ya tenga o no síntomas.

The authors wish to acknowledge with genuine thanks the help and advice given by Dr. G. E. Harmon, of the Detroit Department of Health, in arranging the tables and, in general, giving statistical balance to the work.

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TUBERCLE BACILLI IN THE STOMACH CONTENTS OF HEALTHY, NORMAL ADULTS EXPOSED TO TUBERCULOSIS[1]

C. RICHARD SMITH

The search for tubercle bacilli in the stomach contents of adult patients has become an integral part of the sputum examination program in this and many other tuberculosis institutions. However, in some quarters there still exists reserve and even skepticism as to the positive significance of the test. It is asked, "Does the presence of tubercle bacilli in the stomach necessarily indicate pulmonary tuberculosis or, in fact, tuberculosis anywhere in the body? Could not any one in contact with the disease swallow a few bugs?" It was the object of this study to determine whether tubercle bacilli are likely to be found in the stomach contents of normal persons exposed to the disease.

There is a body of literature on the subject of acid-fast bacilli in the *sputum* of normal, near-normal or nonsick persons. Principally it has emanated from France where the concept, "carriers of tubercle bacilli," has been built up. Cordier (1) classified such "carriers" as: (*1*) Ambulant cases of frank tuberculosis. (*2*) "*Porteurs valides*," that is, carriers who are able-bodied. Here there are few or no symptoms, few or no physical signs, negative or nearly negative roentgenograms. Cordier uses the term "*porteurs valides*" advisedly and in contradistinction to "*porteurs sains*" or healthy carriers which refers more properly to typhoid and dysentery carrier types. (*3*) Cases in which there are accidental emissions of tubercle bacilli from "imperceptible foci" during acute nonspecific inflammatory episodes.

Under Cordier's latter two classifications may perhaps be placed the 21 cases reported by Bezançon, Braun and Meyer (2), 3 described by Faure and Matinier (3), one by Steinberg (4), 4 of Meersseman's cases (5, 6), 2 of Gutmann's (7) and one of Renzo's (8).

Lamache and Dutrey (9) examined the sputum or saliva of 4,115 soldiers and found 3 instances of "*porteurs valides*." Meersseman (5) discovered 1 expectorator of doubtfully virulent bacilli among 84 radiologically normal medical students and 1 of true tubercle bacilli among 80 "healthy", radiologically normal soldiers. In the latter instance, however, a hidden tuberculous focus was proven.

Meersseman (5, 6, 10) speaks of "precocious" and "convalescent" carriers, that is, emitters of bacilli before the appearance of or after the healing of clinical tuberculosis, and describes 2 such cases. Here also may be classified Blume's (11) and one of Gutmann's (7) cases.

Faure and Matinier as well as Meersseman believe expectorators of bacilli having only microscopical pulmonary lesions not discernible by clinical means or those in whom there is a migration of the microörganisms from disease elsewhere in the body to the alveoli of the lungs may properly be designated "true" or "healthy carriers" ("*porteurs sains*"). Lamache and Dutrey insist the presence

[1] From the Barlow Sanatorium, Los Angeles, California.

of tubercle bacilli means tuberculosis; that these cases should be classified as "*cracheurs valides*," that is, spitters who are able-bodied rather than "*cracheurs sains*" or healthy spitters; and that the term "carrier" in the strictest sense should apply to the rhinopharyngeal carrier which is rare, of short duration and always found near tuberculous persons. Gutman claims the existence of "carriers" is proven. Blume feels it improbable that virulent tubercle bacilli can exist in the body without a lesion, that the complete absence of tuberculosis can be proven only by autopsy.

In the United States, Floyd and Novack (12) accept the definition of "carriers of tubercle bacilli" as ". . . individuals harboring microörganisms, virulent or avirulent, but not suffering with the concomitant disease." They record 4 cases having positive sputum and negative X-ray pictures, an incidence of 1 in about 10,000 examinations.

Trudeau and Yeager (13) reported 100 cases having acid-fast bacilli in the sputum but negative or doubtfully positive roentgenograms, gleaned from the Trudeau Sanatorium admission files of the past thirty years. It is noteworthy that in the majority the "positive" reports came from various sources outside the institution prior to the patient's admission and that in three-fourths only a single "positive" was found. Also it should be emphasized that most of the examinations were made in the days when only microscopical methods were employed. The authors believe that, aside from the few instances where bacteriological errors may have occurred, the diagnosis of tuberculosis was valid.

Indeed, most of the writers on this subject do not accept the concept of true carriers in the strictest sense. Rather they consider their patients as examples of obscure tuberculosis. A review of the cases reported gives one the impression that the presence of acid-fast bacilli in the sputum could be accounted for in almost every instance. Either there was a strongly suggestive history; there were physical signs; there was definite or suggestive X-ray evidence of disease; the bacilli were nonpathogenic; or they emanated from an extrapulmonary lesion.

Tubercle bacilli have frequently been found in the *stomach contents* of persons without patent pulmonary tuberculosis. The reports of such findings are particularly abundant for infants and children. Representative are those of Poulsen (14), Wallgren (15), Clausen (16), Opitz (17), Collis and Brockington (18), Gourley (19), Poulsen and Andersen (20), Armand-Delille and Kerambrun (21), Rothstein (22), Lesné, Dreyfus-See and Saenz (23), Davies and Doherty (24), and Floyd and Friedman (25). Almost without exception, however, the test was performed because disease was suspected by reason of history, tuberculin sensitivity, enlarged hilar shadows, "healed" pulmonary lesions or other questionable roentgenographic signs, or even frank extrapulmonary tuberculosis.

Also suspect are most of the adults in whom positive findings have been reported. Thus of 5 such described by Clausen (16) one was an "observation case" and 4 had pleuritis. Gad (26), who found bacilli in 12 per cent of 271 adults "without roentgenographic foci," classified the positive cases as "observation for tuberculosis," "old healed tuberculosis," "pleurisy," and "enlarged peribronchial lymph nodes." Among the 12 cases reported by Webster (27), 11

showed roentgenographically doubtful, old or inactive tuberculosis and, while the X-ray picture in the twelfth was negative, the bacillus isolated was nonpathogenic.

Studies of nonsuspect persons have been much less successful in the demonstration of tubercle bacilli. Robinson and Dunn (28) collected reports on stomach contents examinations in 903 "nontuberculous individuals" with only one positive result. One group includes those suffering from illnesses other than tuberculosis, usually patients in hospitals or sanatoria and often exposed to phthysis. Opitz (17) examined 21 such cases in children, Clausen (16) 14, Davies and Doherty (24) 11 and Gad (26) 23 in adults. All were negative. Stadnichenko, Cohen and Sweany (29) presented a "control" series of 176 sanatorium patients in whom no tubercle bacilli could be found: 46 were tuberculous, but 52 had "normal" X-ray pictures and the remainder had nontuberculosis diagnoses, of which 10 were confirmed by autopsy.

Likewise unsuccessful were Koganas and Nakanas (30) in the examination of 17 nontuberculous but sick adults sent to their tuberculosis service because of mistaken diagnoses. They state, "One may consider the absence of bacilli in the stomachs of these sick persons as certain proof that the tubercle bacilli one does find in the stomach have a pulmonary origin, and that they do not fall there by chance, with eating, for example. These sick people were placed in the intimate neighborhood of patients with positive sputum, and they had had sufficient opportunity to swallow bacilli with their food. We believe the number of bacilli swallowed accidentally is too small to be taken into consideration and that the demonstration of Koch's bacillus in the stomach of a well person is an exception which has no practical value."

On the other hand, Roper and Ordway (31) found virulent tubercle bacilli in 2 instances during the course of stomach examinations on 232 adult sanatorium patients at Metropolitan Life Insurance Sanatorium "entirely free of tuberculous disease of the lungs according to history and by physical and roentgenographic examination of the chest." Although the upper respiratory tracts were searched, bronchoscopic examinations were not carried out. Ordway (32) says "The idea of so-called healthy carriers does not appeal to us because our studies would seem to indicate that a valid positive test obtained by guinea pig inoculation of sputum or gastric concentrate in all probability shows that the individual harbors a tuberculous infection of the respiratory tract."

In a subsequent study at the same institution, Medlar, Ordway and Pesquera (33) discovered acid-fast bacilli in the sputum or stomach contents of 14 out of 333 patients with roentgenologically normal pulmonary fields and in that of 11 out of 146 patients with nontuberculous pulmonary disease. Pathogenic tubercle bacilli were proved in 7 cases of the first group and in 2 of the second. The authors were impressed by the frequency of nonpathogenic acid-fast bacilli. They do not think their results are indicative of what would be obtained by a like survey of "healthy citizens" and are inclined to the view that the tubercle bacillus positive patients in their series represent cases of occult tuberculosis.

A few investigators have performed stomach contents examinations in tuber-

culin-negative infants and children. Wallgren (15) reported the results in 3; Collis and Brockington (18) in 18; Gourley (19) in 68; Rothstein (22) in 10; Davies and Doherty (24) in 4; and Poulsen and Andersen (20) collected the data from several Denmark hospitals on 158 such cases. In every instance, attempts to isolate tubercle bacilli by animal inoculation were unsuccessful. Poulsen and Andersen, however, mention 3 instances known to them where tubercle bacilli were found in infants prior to a subsequently developing allergy. But these authors state, "When lavage shows the presence of tubercle bacilli, the child almost certainly has tuberculosis, and if it can be established that the bacilli do not originate in the fauces (tonsils, adenoids) the tuberculous process must be located in the lungs."

It is difficult to find in the literature deliberate gastric lavage surveys of well, nonhospitalized persons in present or recent contact with tuberculosis. The testing of 6 "healthy" scrub-women by Stadnichenko, Cohen and Sweany (29) would be satisfactory provided clinical examinations including roentgenography were made. Floyd, Novack and Page (34) reported the results of stomach contents cultures and inoculation in 219 well persons sixteen to twenty-six years old in whom there was known or suspected contact with tuberculosis. In many the exposure had ended several years previously while in others it was much more immediate. Serial roentgenograms over a period of one to fourteen years showed epituberculosis in one case, healed primary lesions in 62 and negative lung fields in 130. Although allergy changed in some, 180 were recorded as tuberculin-positive, 39 negative. While there was some question as to the interpretation of animal inoculations, proven viable tubercle bacilli were found in no case.

PLAN OF STUDY

By virtue of an affiliation with several schools of nursing, student nurses come to the Barlow Sanatorium for a training period of six weeks. During this time they perform all bedside nursing duties for active, open cases of tuberculosis. They live on the sanatorium grounds and eat in a sanatorium dining room. The patients as well as the student nurses are given instruction and are under supervision as to hygiene. Mouth covering with absorbent cellulose paper napkins by the patient during cough is insisted upon, although very ill patients frequently break the rule. Sputum is collected in paper cups and burned. The students are warned against touching contaminated hands to the mouth or face, and against eating candy or other food offered by patients. The nursing technique throughout the survey period has included the wearing of gowns during actual bedside care and the frequent washing of hands, especially before eating. In the latter part of the survey (beginning in November, 1940 and including 82 students) 6-ply, 42 threads-to-the-inch gauze masks were worn during bedside care.

Chest roentgenography[2] and Mantoux tests with first and second strength PPD graded according to Aronson were done on arrival; roentgenography,

[2] Interpreted by Dr. R. G. Karshner.

tuberculin tests and chest physical examinations[3] at the time of departure. Beginning in July, 1939 and continuing through October, 1942, gastric lavage was performed on all affiliate student nurses except 3 who refused. In addition 3 other examinations had been done the year previously on students affiliating for four-month periods.

PROCEDURE OF THE TEST

The fasting stomach contents are aspirated in the morning by means of a Levin tube introduced through the nose. The subject is allowed to sip enough water during or after introduction to being the volume of the specimen to between 50 and 100 cc. All equipment and solutions are sterile. The operator wears a clean gown, mask and sterile gloves. The tube is not chilled and it is adequately lubricated with water.

Sufficient 4 per cent sodium hydroxide is added to the aspirated material to make a final concentration of 0.25 per cent. The mixture is shaken ten minutes by a machine with a rate of 240 vibrations per minute and a displacement of 3 inches. The resultant material is divided for culture and inoculation, no microscopical examination being made. The two parts are centrifuged at about 2,000 rpm for ten minutes. Some of the sediment from the first part is cultured directly; the rest after admixture with an equal amount of 2.5 per cent oxalic acid and immediate recentrifuging. In each case the material is planted on two tubes of Petragnani's medium, two drops to a tube.

The sediment from the second part is washed with water, recentrifuged and inoculated subcutaneously into the right flank of a guinea pig.

The cultures are discarded after two months, all growths being checked by Ziehl-Neelsen stain.

Clinically positive animals are autopsied at one month, the others at two months. Visceral tuberculosis and the demonstration of acid-fast rods by smear from the organs or regional lymph nodes are required as evidence of a virulent tubercle bacillus. In all grossly negative animals, pieces of visceral organs are ground up and cultured. Where there is any question, tissue sections are made.

RESULTS

One hundred and fifty-four student nurses were examined. Two were known, rehabilitated cases of pulmonary tuberculosis and so excluded from our survey. Three others were excluded because of newly found, soft shadows in the chest.

The remaining 149 students showed no evidence of active tuberculosis and were considered to be normal, healthy young women. Their average age was twenty-two years. The average number of days of nursing duty at the sanatorium before gastric lavage was thirty-three. Physical examination of the chest was negative except for slightly altered breath sounds in 10, sibilant râles in one, an expiratory wheeze in one and limited or retarded motion of the hemithorax in 2. X-ray films definitely revealed calcified primary lesions in 23. The Mantoux test at the beginning of the service was positive in 64, doubtful in 5 and negative in 80. At the end of the service, 2 of the students previously negative to tuberculin had developed positive and 4, doubtful reactions. Thus 74 were tuberculin-negative at the time of gastric lavage.

[3] By Dr. Franklin S. Reding.

Cultures and animal inoculations of the stomach contents were negative for tubercle bacilli in every one of the 149 cases in which no active disease was demonstrable.

Active pulmonary tuberculosis subsequently developed in 3 of these girls but this was not thought to alter their status as normal persons at the time of the test.

DISCUSSION

For our purposes we shall define a normal, healthy adult as one without active tuberculosis, pulmonary or extrapulmonary, of great or small extent, discernible by clinical means. The presence of healed disease and tuberculin allergy will be considered consistent with the normal state (not applicable to infants and children).

The "normal or contact" carrier (condition) is defined by Park and Williams (35) as one which, following exposure to infection, ". . . may develop without any evidence of active disease. . ." and wherein ". . . the individual possesses at least a slight immunity, but the infectious agent becomes implanted as a simple parasite." The "convalescent carrier" is described by the same authors as a susceptible person in whom the disease develops, recovery takes place, and the infectious agent remains ". . . as a simple parasite, the body being protected from further injury due to the immunity developed in the process of recovery of the disease. . . . Frequently the 'convalescent carrier' state is due to the persistence of chronic foci of inflammation in the crypts of the tonsils, in the gallbladder or elsewhere. Because of the situation of these foci and the character of the local secretions the infectious agent is protected from antibody activity." These definitions apply more especially to agents of acute infectious diseases characterized by well defined, self-limited courses and the development of a powerful immunity in the host, as for instance, typhoid fever, meningococcus meningitis and diphtheria. The bacillus of tuberculosis is a different case. The associated disease has an indefinite course and immune reactions in the host are relatively weak while allergic phenomena are prominent. Thus the immunity of the so-called contact or convalescent carrier would seem less capable of preventing disease changes and at the same time the allergy would tend to stimulate and magnify the production of such changes. Specific tissue reaction to the bacillus, we believe, constitutes the disease *per se* and a residual focus of inflammation in the convalescent must necessarily be considered tuberculosis. Therefore, we prefer to accept only the strictest definition of the term carrier, that is, a normal, healthy person in whom tubercle bacilli are present temporarily or as pure saprophytes. The microörganisms must be available for infection of others and demonstrable in the excretions.

That living, virulent tubercle bacilli may be present in the normal, healthy human body cannot be denied. In 1894 Straus (36) inoculated the nasal secretions of 29 healthy nurses, orderlies, medical students and nontuberculous patients in contact with consumptives on the wards of Charité and Laennec Hospitals in Paris. Nine were positive! More recently, Sergent (37) isolated

the bacilli from the nasopharynges of 5 out of 50 X-ray negative, medical attendants on tuberculosis wards. Modern repetitions of Straus's experiment have, however, usually netted very few positive results. Lamache and Dutrey (9) were unable to find the microörganisms in 39 exposed persons. Bezançon, Braun and Meyer (38) and Katz (39) were likewise unsuccessful in several attempts. Bezançon *et al.* attribute their failure to the greatly improved hygiene of the present day. In the time of Straus, expectoration by patients was apt to be promiscuous, mouth covering during cough uncommon, floor cleaning inadequate, and other protective measures little considered. Persons living or working in such a heavily contaminated environment undoubtedly took into their bodies large numbers of tubercle bacilli. Also, it should be mentioned, Straus did not have available the clinical means, that is, roentgenography, to rule out the presence of small lesions in his subjects.

That bacilli can remain in the body without tissue reaction and as true saprophytes is supported by postmortem studies. Wang (40) isolated virulent bacilli from histologically negative human lymph nodes in 3 out of 32 cadavers. His review of the literature shows similar findings of "latent tuberculosis" of lymph nodes in about 12 per cent of the cases reported. Opie and Aronson (41) inoculated microscopically nontuberculous portions of lungs from persons dying of other causes. This material was "unselected as to tuberculosis elsewhere in the lung." In 25 to 36 per cent, the results were positive. Feldman and Baggenstoss (42) found virulent microörganisms in grossly negative (the contiguous tissue being microscopically negative) lung and lymph node tissue in 3 out of 51 autopsies on persons dead of other causes. In one case there was active extrapulmonary tuberculosis and in the other 2, apparently healed lesions. Sweany, Levinson and Stadnichenko (43) in their report on autopsy studies of 300 bodies dead of causes other than tuberculosis state, "Positive cultures from tissue entirely outside of tubercles were rare and appeared to decrease as the distance increased from active tuberculosis. . . . While it must be admitted that exogenous infection may localize bacilli in lung tissue without any sign of reaction, especially in old fibroid tissue (without reactivity), this work has shown that in our locality it is the exception and not the rule for bacilli to be thus found in tissue."

The postmortem evidence must be interpreted with care. Contamination of normal tissue from diseased lung areas is difficult to rule out. Opie and Aronson were aware of this. In fact tubercle bacilli can be and are conveyed to the lungs from lesions anywhere in the body by the returning venous blood, all of which must pass through the pulmonary capillaries. Feldman and Baggenstoss were obviously aware of this. It would perhaps be wise, then, to exclude all evidence based on postmortem examination of bodies harboring any active tuberculosis. Apparently healed or encapsulated tuberculosis certainly can contain live bacilli whose parasitic nature is temporarily reduced but whose existence as pure saprophytes might be questioned. On the other hand, normal tissues may be contaminated by opening or bruising such near-by encapsulated lesions. Other points to keep in mind are that gross inspection alone cannot be depended upon to establish the absence of disease, especially in lymph nodes; single microscopical sections are not absolute proof of no disease; and, finally,

the actual tissue cultured or inoculated is not examined histologically. In spite of these objections, the evidence is strong that tubercle bacilli may exist in the body without tissue reaction. Whether such microörganisms are shed or excreted in sufficient numbers to constitute the carrier state is another matter.

When acid-fast bacilli are found in the sputum or stomach contents of an apparently normal person the case should be carefully reviewed. Bacteriologically, error may be due to wrong labeling of the specimen by accident or intent. False positive findings can result from improper staining, particularly inadequate decolorization; the presence of live or dead tubercle bacilli clinging to previously used, inadequately cleaned glassware or stomach tubes as demonstrated by Belgorod and Schain (44); or the presence of saprophytic acid-fast bacilli.

Cultures may be wrongly interpreted due to the presence of growths of acid-fast saprophytes when one is unfamiliar with the coherent, friable, nonsmeary tubercle bacillus colonies or when one attempts to obtain a reading in the absence of gross colony formation by staining swab smears made from the medium surface. Questionable cultural growths should be tested by inoculation.

Even interpretation of the results of animal inoculation is subject to error. Visceral disease as well as the demonstration of acid-fast bacilli is necessary for the proof of true tubercle bacillus. Acid-fast saprophytes are capable of producing a local reaction and tuberculin allergy, and they may be demonstrable microscopically at least at the inoculation site. Thus mere demonstration of acid-fast bacilli in the inoculated animal's tissues without visceral tuberculosis does not prove tubercle bacillus.

Nonpathogenic acid-fast bacilli are often indistinguishable microscopically from tubercle bacilli. They are widely distributed in nature and available for inhalation or ingestion. Baldwin (45) was able to isolate them from a number of common fruits and vegetables such as lettuce, celery, strawberries and grapes. Pinner (46) showed the possibility of their being laboratory air contaminants. At Barlow Sanatorium, in our routine examinations for tubercle bacilli, growths of acid-fast saprophytes have been obtained in 1.7 per cent of sputum cultures (performed between November, 1933 and March, 1943) and in 1.4 per cent of stomach contents cultures (performed between January, 1936 and March, 1943). A number of cases have been reported in which the finding of these microörganisms has resulted in the false diagnosis of tuberculosis or of "normal carrier," or it has raised serious question as to the disposition of the patient: see Baldwin (45), Gutmann (7), Meersseman (5), Seaberg and Josewich (47) and Webster (27).

Where there is any question as to the diagnosis, microscopical and even cultural findings should be checked by animal inoculation. To prevent false positive reports on stomach contents examinations due to the presence of acid-fast saprophytes or the cadavers of tubercle bacilli clinging to the stomach tubes, we do not employ microscopical methods at all but only culture and animal inoculation. Sputum concentrations are always controlled by concomitant culture on the same specimen.

When the bacteriological findings are established beyond question in the

apparently normal carrier, possible errors, omissions or inadequacies of the clinical examination should be considered. The standard chest roentgenogram may fail to demonstrate active pulmonary lesions because of small size, structure and composition or location. Potter (48) finds that the rare positive sputum cases with negative roentgenograms usually develop rayable disease in the course of a few days or weeks. In postmortem studies of miliary tuberculosis, Steiner shows that the frequently negative antemortem X-ray pictures in this disease were due to the histological structure of the tubercle, that is, to the epithelioid rather than caseous and fibrous types, more often than to small numbers or small sizes of tubercles.

Stephani and Mollard (50) point out that some lesions of pulmonary tuberculosis are not demonstrable by the ordinary X-ray technique but require special procedures such as exposures from different angles or the use of hard rays to relieve obscuration by bones or other structures. These authors also believe that some disease is radiographically invisible either because of position or because of small size or structure. Lesions at the posterior lung base or in the deep mediastinal cul-de-sac or in the retroclavicular region may be undetectable even with special techniques. Then, they hold, there is a threshold of size below which the disease area is not visible and a softness of structure, as in the early stage of exudation, where the density is insufficiently greater than that of the surrounding tissue to cast a visible X-ray shadow. To be detectable by X-ray, a lesion must, they say, have the "dimensions and structure of a nodule."

Bezançon, Braun and Meyer (2) present several cases in which auscultation revealed bacillus producing disease undemonstrable by X-rays. As we have come to accept the fact of the "inaudible lesion," they say, we must now realize the existence of the "unrayable lesion."

Tracheobronchial or bronchial tuberculosis may be the source of tubercle bacilli in otherwise clinically normal persons. The school of thought, led by the French, supporting the "carrier" concept has largely ignored this possibility. In 1915, Lord (51) was able to find records of 5 proved cases of primary tuberculosis of the trachea and bronchi with no tuberculosis elsewhere. Wide-spread use of the bronchoscope in recent years has shown that bacillus producing disease may exist in the larger respiratory passages with little or no evidence as shown by the ordinary chest roentgenogram. Samson (52), Barnwell, Littig and Culp (53), Ornstein and Epstein (54), and Shipman (55) have described cases illustrating this point. Goldberg (56) concluded, ". . . uncomplicated endobronchial tuberculosis may show no definite findings on the flat or stereo film of the chest. . ."

The nasopharyngeal region can be the source of acid-fast bacilli in an otherwise normal person. Primary tuberculosis of the tonsils or tonsillar disease without X-ray evidence in the chest has been described fairly often. For a discussion of this subject see Long, Seibert and Gonzalez (57). Long *et al.* X-rayed the chests of 35 persons with histologically demonstrated disease in their surgically removed tonsils. The X-ray films were completely normal in 9. We examined roentgenographically the chests of 7 children in whom the surgically removed

tonsils were tuberculous or bacilliferous. The X-ray picture was completely normal in one. Gutmann (7) reported a case in which acid-fast bacilli in the sputum disappeared following surgical removal of tuberculous tonsils. Trenis (58) reported a case in which tuberculous adenoids were proved to be the cause of positive sputum in a girl in whom oblique, lateral, apical detail and Potter-Bucky roentgenography failed to show pulmonary disease. Most authors emphasize the difficulty of detecting tuberculosis in the nasopharyngeal region by visual inspection, bacteriological or histological examination usually being required for a diagnosis.

Another possible source of acid-fast bacilli, especially in stomach contents, is the stomach itself. As is well known, tuberculosis of the stomach is very unusual and as a primary lesion, rare. Chaffin (59) was able to collect from the literature only 54 proved cases through 1937 and about half of these were associated with tuberculosis elsewhere in the body. Sullivan, Francona and Kirschbaum (60) found records of only 2 cases in a series of 11,480 autopsies and of only one among 75,000 surgically removed stomachs, none being primary.

Further clinical investigation in persons with unexplainable positive excretions should include X-ray exposures from various angles and, perhaps, with the Potter-Bucky diaphragm or the Lysholm grid. Endoscopic examination of the trachea and major bronchi should be performed. There ought to be a careful exploration of the nose, throat, ear and cervical lymph nodes. Search for other extrapulmonary foci is indicated. Finally, a series of reëxaminations at perhaps three-month intervals should be carried out for at least a year.

We have performed culture and animal inoculation on 149 clinically normal adults exposed to tuberculosis without finding tubercle bacilli in any case. Admittedly the series is small. Also it is a homogeneous group of uniform sex, age, social and economic status. It is true that the stomach may have discharged its bacillary contents prior to aspiration in some of the subjects but this is also true in the diagnostic tests. Undoubtedly the exposure of our nurses was limited by hygiene but the chances of taking in bacilli were still great, especially in the rooms of very sick patients. Though gauze masks probably stop all but the tiniest droplets of moisture, they are without question readily permeable to the droplet nuclei of Wells and also, certainly, to dust from bed linen, bedclothes and floor. Hair, parts of the face unprotected by the mask and shoes which may contaminate students' living quarters are less important weak points in the hygiene.

Without question tubercle bacilli were breathed in and swallowed by these girls but they were either eliminated, killed, fixed in the tissues, of too feeble viability or not present in sufficient numbers to be recoverable by the methods employed. This shows, I think, that the gastric contents examination is not likely to be positive in the absence of open tuberculosis.

Tubercle bacilli frequently enter the bodies of normal persons. The ubiquity of the disease is proof. But these bacilli are not likely to be recovered by our standard diagnostic tests. Stomach contents (and sputum) examinations by methods that determine the presence or absence of tubercle bacilli are reliable

tests. The finding of tubercle bacilli, with rare exceptions, indicates tuberculosis somewhere in the body, usually in the lungs; but in any case a bacteriological diagnosis has been made. Microörganisms accidentally present are not likely to be detected. In the words of Hoesslein (61), "...where there are bacilli, there exists a patent tuberculosis... *a priori*, a primary settling of tubercle bacilli on mucosa and upper strata would perhaps be possible... In practice we must always assume a destructive process."

That true carriers, in the strictest sense, exist, is indicated by postmortem studies and experiments such as those of Straus. But under modern conditions of hygiene I believe them so rare or of such short duration as not to affect the validity of our diagnostic tests.

Unconsidered diagnosis of "carrier" is dangerous. It leads the clinician into the easy habit of explaining his tubercle bacillus positive cases on this basis when in all probability active, open tuberculosis is present.

SUMMARY

1. Reports in the literature of carriers of tubercle bacilli almost always represent cases of obscure pulmonary or extrapulmonary tuberculosis, or carriers of nonpathogenic acid-fast bacilli.

2. Reports of tubercle bacilli in the stomach contents are rare for nonsuspect persons. In the few cases recorded, the clinical data have not been complete.

3. Examination of the stomach contents by culture and animal inoculation was performed on 149 normal, healthy student nurses attending open cases of tuberculosis. All were negative for tubercle bacilli.

4. Reports of bacteriological and autopsy studies indicate that true carriers of tubercle bacilli exist. But the former were made before the days of modern hygiene and the latter are open to certain technical criticisms.

5. When acid-fast bacilli are reported in the excretions of an apparently normal person, the microscopical and even the cultural findings should be checked by animal inoculation.

6. When tubercle bacillus is proved in the apparent normal, further clinical investigations should include angle and diaphragm or grid X-ray exposures; a careful exploration of the nose, throat, ears and cervical region; endoscopic examination of the trachea and bronchi; and a series of three-month reëxaminations for at least a year.

7. Tubercle bacilli are rarely if ever found in stomachs of healthy, normal persons. Examination of the stomach contents for tubercle bacilli is a reliable and significant test.

SUMARIO

1. Los informes que contiene la literatura de portadores de bacilos tuberculosos casi siempre representan casos de tuberculosis pulmonar o extrapulmonar obscuros, o portadores de bacilos ácidorresistentes anapatógenos.

2. Los informes relativos al hallazgo de bacilos tuberculosos en el contenido gástrico son raros en los sujetos no sospechosos y en los pocos casos comunicados los datos clínicos no han sido completos.

3. En 149 estudiantes enfermeras sanas y normales que asistían casos abiertos de tuberculosis, se verificó un examen del contenido gástrico mediante cultivo e inoculación en animales y todas resultaron negativas en cuanto a bacilos tuberculosos.

4. Existen informes de estudios bacteriológicos y autópsicos que indican la presencia de verdaderos portadores de bacilos tuberculosos, pero los primeros se realizaron en los días anteriores a la higiene moderna y los últimos son susceptibles de ciertas críticas técnicas.

5. Cuando se comunica la presencia de bacilos ácidorresistentes en las excreciones de una persona aparentemente normal, deben comprobarse los hallazgos microscópicamente y hasta mediante la inoculación en animales.

6. Cuando se encuentran bacilos tuberculosos en sujetos aparentemente normales, las investigaciones clínicas ulteriores deben comprender: exposiciones a los rayos X en ángulo y con diafragma o rejilla, una cuidadosa exploración de la nariz, garganta, oídos y región cervical; examen endoscópico de la tráquea y bronquios, y una serie de reexámenes trimestrales por espacio por lo menos de un año.

7. Rara vez o nunca se encuentran bacilos tuberculosos en el estómago de las personas normales o sanas. El examen del contenido gástrico en busca de bacilos tuberculosos constituye una prueba fidedigna e importante.

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SPECIFIC CYTOTOXIC ACTION OF TUBERCULIN

Quantitative Studies on Tissue Cultures

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The present study deals with an evaluation of some quantitative methods for studying bacterial allergy in tissue culture. Hypersensitivity to a number of bacteria has been studied by means of tissue culture methods but tuberculin-sensitive tissues have been studied more widely than others. Rich and Lewis showed that cells from tissues of tuberculous guinea pigs were injured by concentrations of tuberculin which did not affect cells from nontuberculous animals. They employed explants of spleen and buffy coat of the blood. Meyer and Loewenthal found that horse serum did not have any deleterious effect upon explants of tissues from animals previously sensitized to horse serum. Aronson clearly demonstrated the difference between hypersensitivity of the tuberculin type and of the anaphylactic type. He found that tissues from animals sensitized to both horse serum and tuberculin were damaged specifically by tuberculin but not by horse serum. Furthermore Aronson demonstrated certain differences in the specific cytotoxic reactions of animals infected with mammalian and avian strains of *Mycobacterium tuberculosis*.

Moen and Swift described a quantitative method in which splenic explants from normal and tuberculous rabbits were grown in Carrel flasks in tuberculin-free medium and in medium to which tuberculin was added. Daily measurements of the extent of migration of wandering cells were made by ocular micrometric methods and the growth of fibroblasts was recorded by projectoscopic methods. The average areas of the migration zones in each series of cultures or the average areas of fibroblastic growth were compared. The inhibition of growth of tuberculin-sensitive tissue by tuberculin relative to the effect of the same amount of tuberculin on the growth of normal tissue was expressed as a comparative cytotoxic index. By the use of this method Moen and Swift showed that the extent of the specific cytotoxic reaction to tuberculin did not depend on the virulence of the organism used to induce experimental tuberculosis or the duration or extent of the tuberculous infection. Moen and Swift and Moen showed that tuberculin-sensitive tissues in tissue culture retained their specific cytotoxic response to tuberculin even after being transplanted many times over a prolonged period.

In the present study an investigation has been made of various quantitative methods for studying the specific cytotoxic reaction to tuberculin. Three types of tissue, spleen, buffy coat and lymph node, have been found sufficiently homogeneous in cellular composition to insure a fairly regular growth or migration of cells. Two of these tissues, lymph node and the white cell layer of the blood, have been grown in a plasma-clot medium on coverslips. An adaptation of the

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method of Moen and Swift has been used for culturing splenic tissue. The comparative cytotoxic index described by them has been found to be very useful for expressing the relative sensitivity of normal and tuberculin-sensitive tissues to tuberculin. In the present study the extent of growth has been expressed in terms of the radius of the zone of new growth rather than of the total area of the zone of growth.

METHODS

Animals: Adult male rabbits were used exclusively. Explants of lymph node, buffy coat or spleen from a normal rabbit and similar tissue from a tuberculous rabbit were cultured on the same day in medium to which tuberculin was added as well as in medium not containing tuberculin. Blood used in the preparation of tissue culture medium was obtained from nontuberculous rabbits exclusively, usually from rabbits furnishing normal tissue.

The strain of *Mycobacterium tuberculosis* used to cause tuberculosis in rabbits was a strain of the human type isolated from a human kidney at necropsy in April, 1929 (Feldman H439). It was of low virulence for rabbits and was moderately virulent for guinea pigs. Rabbits were given an intravenous injection of 0.1 mg. of a six to eight weeks old culture grown on egg-yolk-glycerin agar. Tuberculin tests were performed at any time after three weeks from the time of inoculation.[3] Animals showing a reaction, that is, an area of induration and erythema 0.5 cm. or more in diameter forty-eight hours after the intracutaneous injection of 1 mg. of Old Tuberculin, were selected for tissue culture studies. These studies usually were carried out within two weeks of the performance of the tuberculin test. The duration of infection in rabbits used in this study was from three to fifty-two weeks.

Tissue culture methods: The general tissue culture methods used were similar to those of King. Media used in all experiments were prepared in a similar manner. Blood was obtained from normal rabbits under sterile conditions either by cardiac puncture or by carotid cannulation with the animal under light ether anaesthesia. Graded amounts of heparin were added to 10 cc. portions of blood in order to obtain plasma and buffy coat, and serum was prepared from the remainder of the blood for use in making serum extract of chick embryos. Serum-chick-embryo extract was prepared by extracting chick embryos of eight days of incubation with normal rabbit's serum in the proportion of one embryo to 5 cc. of serum. Tubes containing plasma and serum-chick-embryo extract respectively were packed in ice until needed for making cultures.

Two different lots of tuberculin were used in the cytotoxic studies. They were preservative-free mammalian tuberculin of Old Tuberculin strength, obtained from the Bureau of Animal Industry of the United States Department of Agriculture. Sample A was used in a final dilution of 1:500, a concentration which caused inhibition of tuberculin-sensitive tissue without affecting the growth of normal tissue. Sample B was found to be approximately twice as strong as sample A in its inhibitory effect on tuberculous tissue and as a result it was used

[3] The tuberculin was injected intracutaneously in the region of the back.

in a final concentration of 1:1,000. Before the cultures were made, a suitable dilution of Old Tuberculin in Tyrode's solution was added to half of the serum-chick-embryo extract to comprise one-tenth of the final volume of medium used for cultures of lymph node and buffy coat, and one-twentieth of the volume of the medium used in Carrel flask preparations. A similar volume of Tyrode's solution without tuberculin was added to the remaining tissue extract.

Preparation of buffy coat cultures: Soon after the plasma had been removed from heparinized blood of the normal rabbit, a tube showing the most satisfactory white cell layer was selected. The buffy coat plaque was removed, fragmented and placed in Tyrode's solution. Fragments measuring approximately 1.5 to 2.0 mm. across were matched for size and placed in two groups of eight fragments each. Explants of buffy coat were prepared in a similar manner from the blood of tuberculous rabbits. Cultures were made as soon as possible after the fragments had been prepared. Each explant was washed in Tyrode's solution and placed on a 22 mm. round coverslip in a clot consisting of one drop of plasma and three drops of serum-chick-embryo extract. The coverslip was secured to a heavier glass slide by a small drop of saline solution. One series of eight explants from each animal was placed in medium not containing tuberculin and the remaining series from each rabbit was placed in medium containing Old Tuberculin. All cultures comprising an experiment were completed in as short a time as possible. Each culture was covered with a hollow slide rimmed with petrolatum and then sealed with a mixture of paraffin and petrolatum. Cultures were incubated as lying drops at 37°C. for twenty-four hours.

Determinations of the extent of migration of leucocytes were made with the use of an ocular micrometer at a magnification of 60 times. A measurement was made of the radius of the zone of migration from the edge of the fragment to the outer limit of migrating cells (135 ocular micrometer units = 1 mm.). The average value in ocular micrometer units was found for each series of eight explants and a determination was made of the percentage variation of the extent of migration of cells in medium containing tuberculin and in tuberculin-free medium. The cytotoxicity of tuberculin for tuberculous cells relative to its effect on normal cells was expressed by means of a comparative cytotoxic index:

$$\text{Comparative Cytotoxic Index} = \frac{\text{Av. migration (N)}}{\text{Av. migration (N + OT)}} \times \frac{\text{Av. migration (S + OT)}}{\text{Av. migration (S)}}$$

in which N = cells from normal tissue and S = cells from tuberculin-sensitive tissue. A numerical value less than 1 is an indication that tuberculin has a specific damaging effect on tissue from tuberculous animals.

After final measurements had been made, cultures were fixed in Zenker formol solution and stained by the Dominici technique. In some instances measurements were made and cultures fixed for sectioning at two-hour intervals throughout the twenty-four-hour period of incubation.

Preparation of cultures of lymph node: Tissue was removed under sterile conditions from the mesenteric lymph node of normal rabbits as soon after death

as possible. Explants were prepared and those measuring between 1.5 and 2.0 mm. across were matched for size and placed in Tyrode's solution in two groups of eight fragments each. Explants were prepared in a similar way from tissue obtained from tuberculous rabbits. Cultures of lymph node were made in a manner identical with that described for buffy coat cultures. Quantitative determinations of the extent of migration of lymphoid cells were made in the manner already described.

Preparation of cultures of spleen: Fat and mesentery were removed from the spleen, which was fragmented and placed in Tyrode's solution. Explants measuring approximately 1 to 2 mm. across were placed in two matched groups of twelve fragments each. Explants of the spleen of a tuberculous rabbit and a normal rabbit were prepared in a similar fashion. Cultures were placed in D5 Carrel flasks and consisted of 0.5 cc. of plasma, 1 cc. of tissue extract and four explants of spleen placed in the medium before clotting occurred. Three flasks, each of which contained four fragments, or a total of twelve fragments, were used for each experimental condition. One series of explants from the normal rabbit and one series from the tuberculous rabbit were cultured in normal medium and the remaining series from each rabbit was cultured in medium containing tuberculin. All cultures comprising an experiment were completed in as short a time as possible. Flasks were closed with rubber stoppers and when clotting was complete a camera lucida drawing was made of the outer edge of each fragment at a magnification of $\times 7$. Cultures were incubated at 37°C. for six days.

A group of experiments was done in which normal splenic tissue only was used in order to observe the variation of growth resulting from the technique alone. A series of normal explants was planted in tuberculin-free medium and another series was planted in medium containing tuberculin, as in the experiments described previously. However, instead of preparing similar cultures with explants from tuberculous animals, duplicate cultures were made and the results were expressed in terms of a comparative cytotoxic index, just as in the case of experiments with tuberculous tissue. It was also possible to observe the variation of the extent of migration of cells in the two series of normal cultures growing in normal medium.

Measurements of migration or growth of cells were made as follows: The extent of migration of wandering cells was measured at twenty-four-hour intervals for the first four days with the use of an ocular micrometer. The results were expressed in terms of a comparative cytotoxic index as described previously. Measurements of fibroblastic growth were made on the sixth day. A camera lucida drawing of the outer edge of the zone of fibroblastic growth was made at a magnification of $\times 7$. The areas of the camera lucida drawings of the explants and the growth zone were determined with a planimeter and recorded in planimeter units. From these measurements the average radius of the zone of new growth was determined for each explant and an average value was obtained for each series of twelve explants. The comparative inhibition of the growth of fibroblasts from normal and tuberculin-sensitive tissue was expressed as a compara-

tive cytotoxic index. In some instances measurements of fibroblastic growth could not be made because the new growth had pulled away from the clot in a number of cultures.

RESULTS

Pathological characteristics of the experimental infection: The infection produced in rabbits by the strain of *Mycobacterium tuberculosis* used in these experiments was very mild and did not cause death in any instance. Most of the infected animals gained weight and appeared to be in good condition even when they were kept for several months. Rabbits killed during the first few weeks of infection showed a moderate number of small tubercles, most commonly in the lungs, liver, kidneys and spleen, with an enlargement of the spleen to two or three times the normal size. After the first two or three months of the disease the spleen decreased in size but, although tuberculous lesions were often absent, a certain degree of splenomegaly usually persisted. A few small tubercles usually could be found in the lungs and frequently in the cortex of the kidney at this time. In animals surviving for several months, macroscopical lesions were sometimes absent altogether.

Microscopically, the tuberculous lesions were chiefly characteristic of the so-called hard tubercle without evidence of necrobiosis. "Foam cells" were commonly present. The tubercles were usually discrete and encapsulation was a notable feature, especially in the liver. Extensive necrosis with calcification occurred infrequently and, when present, such changes were limited to the lungs.

Tissue culture observations: Buffy coat cultures: Within an hour after the cultures had been made, many granulocytes appeared in the plasma clot surrounding the explants. The zone of migrating cells widened rapidly during the first eight hours of incubation but then showed a diminishing rate of extension during the rest of the period of observation. The amount of Old Tuberculin used in these tests did not produce a significant decrease of the migration of normal cells at any time during incubation. On the other hand, the same amount of Old Tuberculin caused a definite inhibition of leucocytes from tuberculous rabbits. This inhibition was evident at the time the first measurement was made at the end of the second hour of incubation and continued throughout the twenty-four hour period.

Microscopical examination of the stained sections did not show any qualitative differences between cultures of leucocytes of normal rabbits, growing in the presence or absence of tuberculin, and tuberculin-sensitive leucocytes in tuberculin-free medium. In all three series the wandering cells of the outer migration zone were chiefly granulocytes (pseudo-eosinophils of the rabbit) with an occasional monocyte. Near the explant were varying numbers of lymphocytes. Most of the pseudo-eosinophils appeared to be intact at the end of twenty-four hours of incubation; however, a small portion showed nuclear disintegration and absence of cytoplasmic granules.

Cultures of cells from tuberculous animals to which tuberculin had been added showed degeneration of some of the granulocytes early in the incubation period, with an increasing number of degenerated cells as incubation progressed. There

was a characteristic disappearance of cytoplasmic granules with no abnormality of nuclear arrangement in many instances but toward the end of the twenty-four hour period a large proportion showed nuclear disintegration as well. A small number of lymphocytes also had degenerated. The rest of the lymphocytes in cultures of this series appeared to be more stretched out and ameboid than in control cultures. Cytoplasmic processes of lymphocytes were more numerous and irregular in shape than in cultures not containing tuberculin. The number of monocytes present was too small to allow any conclusion to be made regarding their relative sensitivity to tuberculin. Although degenerative changes were

TABLE 1

Effect of Old Tuberculin, sample A, on average radius of migration zone of cultures of buffy coat from normal and tuberculous rabbits. Values are in ocular micrometer units

EXPERIMENT	NORMAL RABBIT EXPLANTS		TUBERCULOUS RABBIT EXPLANTS	
	OT not present	1:500 OT	OT not present	1:500 OT
1	191	206	214	199
2	262	247	265	151
3	307	317	431	337
4	218	228	293	208
5	410	387	276	190
6	384	372	325	161

TABLE 2

Relative effect of Old Tuberculin on migration of granulocytes from buffy coat explants of normal and tuberculous rabbits

EXPERIMENT	PERCENTAGE VARIATION FROM CONTROLS		COMPARATIVE CYTOTOXIC INDEX	DURATION OF INFECTION
	Normal explants	Test explants		
				weeks
1	+8	−7	0.86	9
2	−6	−43	0.60	4½
3	+3	−22	0.76	5
4	+5	−29	0.68	8
5	−6	−31	0.73	8
6	−3	−50	0.51	8½

particularly evident in the case of the pseudo-eosinophils, the proportion of granulocytes to lymphocytes in the migration zone appeared to be about the same as in control cultures. Since granulocytes have a tendency to degenerate within a short time when grown in tissue culture, it is difficult from quantitative observations alone to determine to what extent granulocytes are more sensitive than lymphocytes to the specific cytotoxic action of tuberculin.

The results of twenty-four-hour measurements of the extent of migration are recorded in tables 1 and 2. There were significant differences between the average migration rates of explants from individual rabbits growing in medium without tuberculin. At times the greater motility occurred in the normal group

and at other times in the tuberculous group. There was also much variation of the degree of inhibition of migration of cells from individual tuberculous rabbits by the same amount of tuberculin. This did not appear to be related to the duration of the infection.

Lymph node cultures: The migration of wandering cells from lymph node explants was not as rapid, and often not as extensive, as in the case of blood leucocytes. An inhibition of migration of tuberculin-sensitive cells in the presence of tuberculin was evident early and continued throughout the twenty-four hour incubation period. The migration zone in all cultures consisted chiefly of lymphocytes of various sizes, among which could be seen an occasional granulo-

TABLE 3

Effect of Old Tuberculin, sample A, on average radius of migration zone of cultures of lymph node from normal and tuberculous rabbits. Values are in ocular micrometer units

EXPERIMENT	NORMAL RABBIT EXPLANTS		TUBERCULOUS RABBIT EXPLANTS	
	OT not present	1:500 OT	OT not present	1:500 OT
1	200	194	211	181
2	202	195	196	171
3	228	256	222	204
4	254	249	233	190
5	205	231	280	246

TABLE 4

Relative effect of Old Tuberculin on migration of lymphocytes from explants of lymph node of normal and tuberculous rabbits

EXPERIMENT	PERCENTAGE VARIATION FROM CONTROLS		COMPARATIVE CYTOTOXIC INDEX	DURATION OF INFECTION
	Normal explants	Test explants		
				weeks
1	−3	−14	0.88	16
2	−3	−13	0.90	16
3	+12	−8	0.82	17
4	−2	−18	0.83	3
5	+13	−12	0.78	9

cyte. Tuberculin-sensitive cells from cultures containing tuberculin showed a small proportion of degenerated cells and the rest of the lymphocytes characteristically showed elongated nuclei and distorted cell outlines. Table 3 presents the results of twenty-four-hour measurements of migration, and the relative degree of inhibition of the normal and test series of explants is shown in table 4. The relative inhibition was not as great as in the series of experiments with buffy coat.

Cultures of spleen: Microscopical examination of cultures of normal explants in tuberculin-free medium showed the following sequence of events: Soon after the cultures had been made, small wandering cells began to migrate from the explant into the plasma clot. Most of these cells were granulocytes but within

three or four hours many lymphocytes also were present in the migration zone. At the end of twenty-four hours of incubation some of the granulocytes were dead and on the second day many granulocytes and some of the lymphocytes had degenerated. The edge of the migration zone at twenty-four hours of incubation consisted chiefly of granulocytes with a few lymphocytes and an occasional monocyte present. There was some extension of migration of the small wandering cells on the second day. Large wandering cells or macrophages appeared near the explant on the second day and at seventy-two hours of incubation had engulfed most of the cell debris in the migration zone. By the fourth day the macrophages had extended far beyond the boundary of leucocytic migration and had formed a roughly circular zone several millimeters in width around each explant. After the fourth day the macrophages became larger and more granular in appearance than before and showed little further migration. Fibroblasts appeared near the fragment on the second or third day and by the fourth or fifth day had formed irregular sheets of compact cells.

Cultures of normal spleen to which tuberculin had been added showed the same distribution of cells as normal cultures without tuberculin. Degeneration of granulocytes was sometimes noticeably accelerated and lymphocytes and macrophages were often somewhat ameboid and irregular in cell outline. There was no change in the appearance of fibroblasts. Cultures of spleen of tuberculous rabbits growing in medium not containing tuberculin resembled control cultures during the first twenty-four hours of incubation. The extent and appearance of the zone of small wandering cells were similar in the two groups. However, macrophages from explants from tuberculous rabbits appeared earlier and migrated farther than macrophages from explants of the spleen of normal rabbits.[4] Fibroblastic growth was not more extensive than in normal cultures.

The addition of tuberculin to cultures of spleen from tuberculous rabbits caused distinct changes in the appearance of the cultures. The area of small wandering cells was almost as dense as in control cultures but was not as extensive and a large proportion of the granulocytes showed degenerative changes. Macrophages did not appear in these cultures for several hours after they were visible in control cultures and they were few, even on the fourth day of observation. Their phagocytic activity was also decreased and the result was that small cells and cellular debris were not picked up by the macrophages but remained in the migration zone.

The experiments done with normal rabbit spleen exclusively made it possible to observe the variation occurring in the growth of various cell types. When a comparison was made of the migration of small cells occurring at twenty-four hours in the two groups of normal explants growing in normal medium, the variation did not exceed 10 per cent. The variation of migration of macrophages measured at ninety-six hours of incubation did not exceed 8 per cent in any ex-

[4] A "stimulated" activity of the large wandering cells has been observed in nontuberculous animals that have suffered recently from other experimental or naturally acquired infections. Tuberculin does not affect these cells to a greater degree than cells from a normal rabbit not showing an increased motility.

TABLE 5

Relative effect of Old Tuberculin, sample A, 1:500, on duplicate cultures of normal rabbit spleen. Comparative cytotoxic index

EXPERIMENT	WANDERING CELLS, HOURS OF INCUBATION				FIBROBLASTS, 6 DAYS
	24	48	72	96	
1	0.93	0.99	0.98	1.09	
2	0.93	0.80	0.83	1.03	
3	0.84	0.83	1.04	0.97	1.28
4	1.17	1.08	0.91	0.94	1.11
5	0.81	1.00	0.90	1.01	0.95
6	1.22	1.06	1.01	0.99	1.07
7	1.08	0.98	0.96	0.95	0.98
8	0.98	1.05		1.06	
9	1.00	1.13	1.16	1.08	1.16
10	1.10	0.99	1.06	0.98	

TABLE 6

Results of an experiment on the effect of Old Tuberculin on the growth and migration of cells from splenic explants of normal and tuberculous rabbits

	AVERAGE RADIUS OF MIGRATION ZONE OF WANDERING CELLS IN OCULAR MICROMETER UNITS, HOURS OF INCUBATION				AVERAGE RADIUS OF FIBROBLASTIC GROWTH ON 6TH DAY, PLANIMETER UNITS
	24	48	72	96	
Normal explants	360	437	450	497	40
Normal explants + OT	384	487	464	512	42
Test explants	296	421	524	603	40
Test explants + OT	232	292	307	381	24
Comparative cytotoxic index	0.68	0.62	0.45	0.50	0.57

TABLE 7

Comparative cytotoxic effect of Old Tuberculin, sample A, 1:500, on growth and migration of cells from explants of spleen of normal and tuberculous rabbits. Comparative cytotoxic index

EXPERIMENT	WANDERING CELLS, HOURS OF INCUBATION				FIBROBLASTS, 6TH DAY OF INCUBATION
	24	48	72	96	
1	0.82	0.86	0.41	0.64	
2	0.86	0.87	0.86	0.62	
3	0.88	1.07	0.68	0.67	
4	0.93	0.88	0.62	0.60	
5	0.91	0.74	0.60	0.45	
6	0.98	0.95	0.70	0.73	0.69
7	0.68	0.62	0.45	0.50	0.57
8	0.74	0.86	0.74	0.70	0.51
9	0.90	0.86	0.52	0.47	0.38

periments in this group. Growth of fibroblasts was much more irregular: the variation between two groups of normal cultures was at times as great as 20 per cent. The addition of tuberculin to normal tissue caused some increase of variation from the normal but at times there was some stimulation of migration of cells in cultures containing tuberculin and at other times migration was less extensive than in cultures not containing tuberculin. Table 5 records the difference in the effect of tuberculin on the growth and migration of cells from two normal series of explants relative to the activity of cells from normal tissue in tuberculin-free medium.

Details of a typical experiment with normal and tuberculous tissue are presented in table 6 in order to show the quantitative changes taking place from day to day. Other experiments with normal and tuberculous tissue followed the same general pattern (tables 7 and 8). Cells from tuberculous tissues were almost always specifically inhibited by tuberculin. This was true for all types of

TABLE 8

Comparative cytotoxic effect of Old Tuberculin, sample B, 1:1,000, on growth and migration of cells from explants of spleen of normal and tuberculous rabbits. Comparative cytotoxic index

EXPERIMENT	WANDERING CELLS, HOURS OF INCUBATION				FIBROBLASTS, 6TH DAY OF INCUBATION
	24	48	72	96	
1	0.71	0.83	0.71	0.41	
2	0.80	0.73	0.52	0.42	
3	0.90	0.88	0.67	0.76	0.63
4				0.58	0.69
5				0 66	0.51
6				0.71	0.64
7				0.46	0.53

cells arising from the spleen. Macrophages were more sensitive to the action of tuberculin than granulocytes or lymphocytes, and fibroblasts growing under these conditions were inhibited as much as macrophages. There was much variation in the degree of inhibition of cells from different tuberculous rabbits by the same amount of tuberculin. There was no relation between the relative cytotoxic response to tuberculin and the duration of the tuberculous infection in the test animal (chart 1).

COMMENT

The results of these experiments confirm the conclusions of previous investigators that wandering cells and fibroblasts of tuberculous animals show a specific cytotoxic response to tuberculin. The view of Rich and Lewis that lymphocytes appear to be somewhat less susceptible to the damaging effect of tuberculin than polymorphonuclear leucocytes is also confirmed. That the cells of tuberculous animals are not specifically inhibited by a number of other noxious agents has

been shown adequately by Moen and Swift and Moen. Cultures of lymph node and buffy coat appear to be satisfactory for quantitative tissue culture studies. The degree of variation of migration among lymph node cultures is usually less than in the case of buffy coat cultures. However, in this series of experiments, explants of normal lymph node with tuberculin added showed stimulation of migration in two instances and the results were not as uniform as in the series of normal buffy coat cultures with tuberculin added. By using the white cell layer of the blood several determinations may be done with blood from the same animal. This technique may also be applied to buffy coat obtained from the

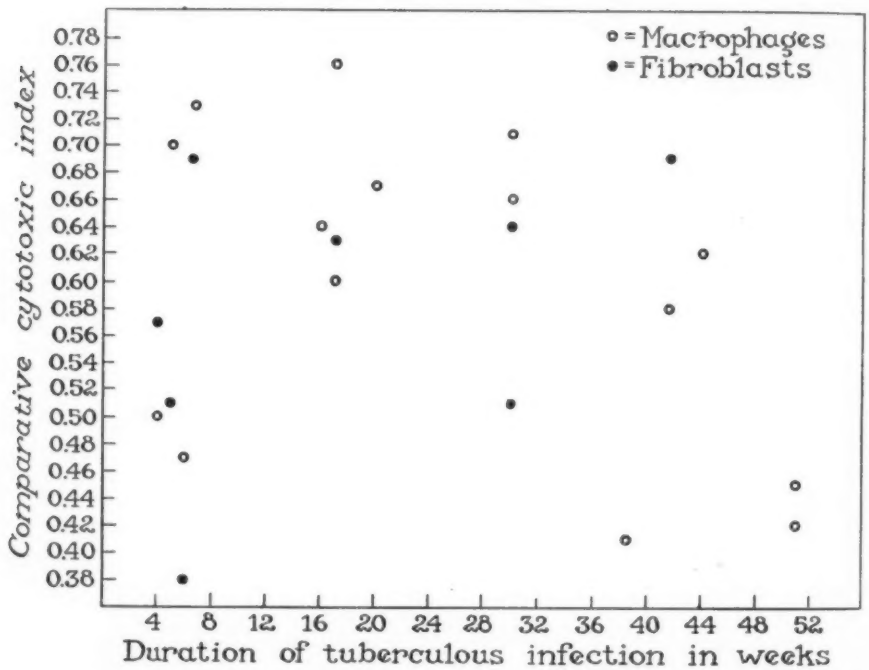

CHART 1. Relation of duration of tuberculous infection to specific cytotoxic effect of tuberculin.

blood of patients and affords a convenient source of cells for quantitative cytotoxic studies.

In general the results of experiments with splenic tissue are in agreement with the work of Moen and Swift. Tissue taken from tuberculous rabbits early in the experimental disease, when visceral lesions were more numerous, was not more sensitive to tuberculin than tissue removed late in the disease when no visceral lesions could be seen grossly. In all experiments in the present study macrophages from tuberculous animals migrated farther in normal medium than macrophages from normal animals, whereas Moen and Swift noted a depressed motility of macrophages from tuberculous animals during the toxic stage of the infection. The experimental tuberculosis induced in rabbits in the present study

may have been too mild to produce a toxic phase even when the infection was most severe. In cultures of spleen the large wandering cells appear to be the best indicator of sensitivity to tuberculin. They are more sensitive to tuberculin than the small wandering cells and the normal variation of their migration is less than the variation present in the growth of fibroblasts. Boundaries of the migration zone of macrophages are distinct and measurements are easily made.

Rich and Lewis observed that, when strong concentrations of tuberculin were added to tissue cultures containing splenic explants from tuberculous animals, the migration of small and large wandering cells could be prevented entirely but that growth of fibroblasts would occur. They concluded that wandering cells are more sensitive to the toxic action of tuberculin than fibroblasts. In the present study concentrations of tuberculin were used that would produce partial inhibition of the growth of cells from the spleen. Under these conditions macrophages and fibroblasts from tuberculous animals appeared to be equally sensitive to the action of tuberculin.

The method of Moen and Swift, with modifications described in this study, has been used in investigating the specific cytotoxic effect of different chemical fractions of Old Tuberculin and has also been used in determining the tuberculin sensitivity of cells from animals in various states of hypersensitivity. The results of these studies will be reported.

SUMMARY AND CONCLUSIONS

Some quantitative tissue culture methods have been investigated for the purpose of determining their usefulness in studying bacterial allergy. Experiments with cultures of blood leucocytes or explants of mesenteric lymph node or spleen of the rabbit have shown that these tissues are suitable for demonstrating the specific cytotoxic action of tuberculin. The following conclusions are drawn:

1. The results of these experiments confirm the observations of other investigators that cells of tuberculous animals are damaged by a concentration of Old Tuberculin that does not affect cells from normal animals. The deleterious effect of tuberculin was shown by a decrease of the extent of migration or growth of tuberculin-sensitive cells in tissue culture and an increase of cellular degeneration.

2. Granulocytes from the blood of tuberculous rabbits were more sensitive than lymphocytes to the specific cytotoxic action of tuberculin.

3. Macrophages and fibroblasts arising from splenic tissue were inhibited to the same degree and were more sensitive to tuberculin than granulocytes and lymphocytes.

4. The methods described are suitable for quantitative tissue culture studies on bacterial hypersensitivity.

SUMARIO Y CONCLUSIONES

A fin de determinar la utilidad de las mismas en los estudios de la alergia bacteriana, se han investigado algunas técnicas cuantitativas de cultivos de tejidos, habiendo demostrado los experimentos realizados con cultivos de leucocitos

sanguíneos o de explantes de ganglios linfáticos mesentéricos o de bazo del conejo que dichos tejidos son apropiados para demostrar la acción citotóxica específica de la tuberculina. Del trabajo sácanse las siguientes conclusiones:

1. Los resultados de estos experimentos confirman las observaciones de otros investigadores en el sentido de que las células de los animales tuberculosos son lesionadas por la tuberculina antigua a una concentración que no afecta las de los animales normales. El efecto nocivo de la tuberculina quedó demostrado por la disminución de la migración o proliferación de las células tuberculinosensibles histológicas y por el aumento de la degeneración celular.

2. Los granulocitos procedentes de la sangre de los conejos tuberculosos mostráronse más sensibles que los linfocitos a la específica acción citotóxica de la tuberculina.

3. Los macrófagos y fibroblastos del tejido esplénico se inhibieron en la misma forma y se mostraron más sensibles a la tuberculina que los granulocitos y los linfocitos.

4. Las técnicas descritas son también apropiadas para hacer estudios cuantitativos de cultivos de tejidos sobre la hipersensibilidad bacteriana.

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OXYGEN LAVAGE OF THE PLEURAL SPACE[1]

A Note on Technique

JAMES F. B. ZWEIGHAFT

Welkind and Herman (1) have demonstrated the value of oxygen lavage of the pleural space. Before lavage the space contains nitrogen (over 85 per cent), carbon dioxide and oxygen; after efficient oxygen lavage the oxygen content is found to have risen to 90 per cent or more. Nitrogen is slowly absorbed, oxygen rapidly. Thus a great reduction of pressure in the space is obtained and the lung attempts to fill the space. Maximum expansion is commonly reached on the third or fourth day; if not complete, the process may be repeated.

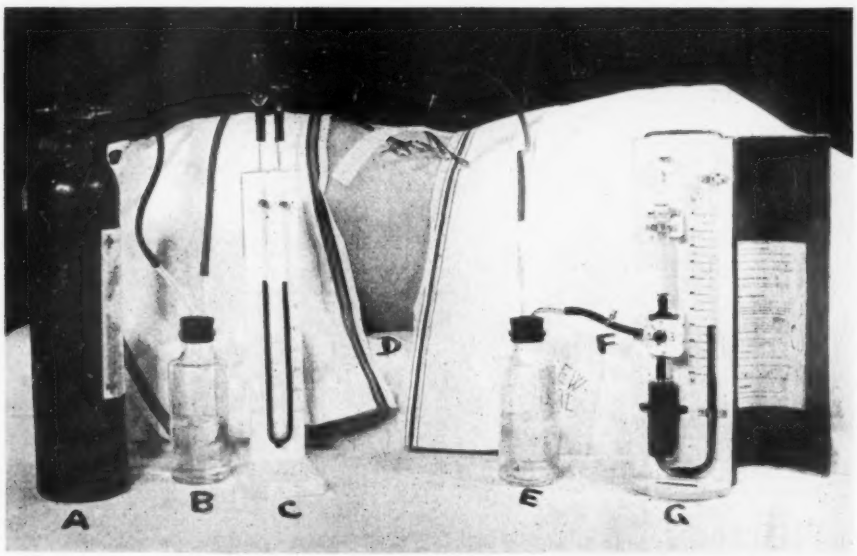

FIG. 1

Oxygen lavage is now widely used and the technique varies considerably in different hospitals. We believe we have developed one which combines simplicity with safety. The need for some form of safety-valve becomes apparent when we consider the high pressure of the gas in the supply tank; should any blockage occur in or beyond the outlet needle, or should the rate of flow through the inlet needle be suddenly increased by any cause, the pressure in the pleural space would rise to dangerous levels. This is more than a purely theoretical consideration. We recently heard of a case where the intrapleural pressure suddenly rose to such a height that both needles were blown out of the chest; the patient developed a massive haemothorax and was in a critical condition for several days.

[1] From the Medical Service of Dr. George G. Ornstein, Sea View Hospital, Staten Island, New York.

Our apparatus consists of a supply tank (A), which feeds the gas into a bubble-bottle (B), which serves as a rate-of-flow gauge. This bottle is connected by a T-tube to the inlet needle in the pleural space of the patient (D), and to the manometer (C) which also acts as a safety valve. The outlet needle leads to the sampling bottle (E). A two-way valve (F) connects the sampling bottle to the outside air or to the oxygen analyzing apparatus (G), depending on the position of the valve.

Bottles (B) and (E) are of 500 cc. capacity and are half full of water. Their inlet tubes project about an inch below the surface of the water; their outlet tubes are well above the surface. All connections are made with one-fourth-inch glass tubing and suitable rubber tubing. Number 18-gauge needles are used in the pleural space; these are clamped in haemostats which are secured to the chest wall by strips of adhesive. The water manometer (C) is a U-tube, one limb ending in the T-tube, the other in a thistle. The limbs are about 30 cm. long, and the device should be mounted on a board and fitted with a scale graduated in cm. of water. The point at which this safety valve will "blow off" depends of course on the amount of water introduced; we have found it convenient and safe to have this occur at a pressure of about 15 cm. When the safety valve is functioning as such, the water collects in the thistle and the excess gas bubbles through it to escape to the outside air; when the proper pressure is restored, the water returns to its original position in the U and the device functions again as a manometer.

The largest pleural spaces that we have encountered are efficiently lavaged, that is, contain an oxygen concentration of 95 per cent or more, half an hour after starting the flow, with the data given; smaller spaces naturally take less time. A convenient but not essential check is the oxygen analyzer. The one we use is made by the Oxygen Equipment Manufacturing Company of New York and has proven sufficiently accurate for this type of work; directions come with it; its accuracy is said to be $\pm$ 3 per cent. The two-way valve (F) is left open to the outside air while the lavage is in progress. When samples of gas from the pleural space are to be taken, this valve is closed and then connects the sampling bottle directly to the analyzer (G).

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AMERICAN TRUDEAU SOCIETY

Report of the Membership Committee

Dr. Harold G. Trimble, *Chairman*

Dr. Henry D. Chadwick — Dr. Paul P. McCain

In accordance with instructions from the Council, your Membership Committee has not only studied and referred to the Council for action applications that have come to us, but also has actively promoted the acquisition of new members.

Up to the date of this meeting (May, 1944) our membership stands as follows:

Members May, 1943	1,714
Deaths and resignations	15
Dropped for nonpayment of dues	32
New members	340
Total membership as of this date	2,007

Of these, 261 are known to be in the armed forces.

The Council has set up the method of procedure of passing on new members. As the application blanks come in, they bear the name of two references given by the applicant himself. These data are referred to the Advisory Board member and/or the Council member in that respective area. If the man is known to him, he gives us his comments; if not, we expect him to find out about the individual and give us his recommendations. With this information the Membership Committee is in a position to make suitable recommendations to the Council for election.

Your Membership Committee has been desirous of promoting better relations and increased membership through the Pan-American countries. We are making certain recommendations toward this end. These are in the process of consideration by the Policy Committee of the Society, a report of which they should give at this meeting.

The Membership Committee is in receipt of an occasional letter from a member who does not seem to understand that the Trudeau Society is an inclusive organization, that is, its membership is open to all doctors of Medicine who have an interest in diseases of the chest, and that it is not an exclusive organization, that is, one composed of chest specialists alone. These letters have been answered individually, and a suitable explanation has been given in each instance.

Our best source of new members this year has been the direct request for names to our existing membership list, plus the very active interest of our Council and Advisory Board members. Our New York office has prepared for them many personal letters to be sent out over their signatures. This procedure has been productive of good results, and the increase in our membership is largely the result of their activities. Correlating these functions in the New York office, Doctor Guild and Mr. Lascelle have done most of the actual physical work involved. The Membership Committee is very grateful to them for their earnest efforts.

AMERICAN TRUDEAU SOCIETY

Report of the Committee on X-ray Apparatus and Technique

Dr. Ezra Bridge, *Chairman*

Dr. F. Maurice McPhedran
Dr. D. O. N. Lindberg
Dr. Hollis E. Potter
Homer L. Sampson, Sc.D.
S. Reid Warren, Jr., E.E.D.
Edward S. Gunson, R.T.
Dr. William H. Weidman

During the year the Committee considered stereoscopy, planigraphy, reproduction of chest roentgenograms and the control of X-ray exposure by a photo-electric device. Two new members were added: Dr. Hollis E. Potter of Chicago and Mr. Edward F. Gunson of Rochester, New York, the latter representing the American Society of X-ray Technicians. The one meeting was held in New York City, November 17, 1943.

Photo-timer: Dr. Russell H. Morgan of the University of Chicago described at our New York City meeting his method of producing comparable densities by photo-electric control of X-ray exposure times. This development, the Committee thinks, will be of assistance to all of us who study the comparative value of photo-roentgenograms made in different parts of the country.

Stereoscopy: The principles of stereoscopy were reviewed and new applications debated, especially those brought forward by the Doctors Edward and Milton Klein. It was felt that stereoscopic results obtained in our field could be definitely improved if the principles laid down by the investigators of former days were followed in design of apparatus and in technique of exposure. Our recommendations will be made available in future studies.

The report on stereoscopy, presented last year by Dr. Homer L. Sampson, was amended to read: "In the study of chest films there are wide limits in the relations between tube shift, focus-film distance and stereoscopic viewing distance that are of value in practice. These relations have an exact physical bais for each object-film distance. This relationship is the foundation of the perception and exact recording of lesions."

Planigraphy: The following statement by Dr. F. Maurice McPhedran was accepted as bearing pertinently on the broad field of planigraphic technique: "Occasionally great difficulties are presented in the diagnosis by planigram of cavities of all sizes, but particularly small cavities (less then 1 cm.). In many cases the diagnosis will rest upon the enlargement or contraction of the space interpreted as cavity; then it is seen, in harmony with former observations on cavity contraction, that those cavities that are fixed at any point tend to move toward that fixed point as they contract, so that the plane of maximum diameter is displaced toward the point of fixation. Therefore, in follow-up of small cavities, planes of ½ cm. or less are essential to keep the final stages in view.

"A planigraphic machine allowing the patient to be examined reclining at an angle or 45 degrees would permit the recording of fluid levels, without the dis-

advantages of vertical planigraphy. Only if the patient is held by gravity against the planigraph table, as in the recumbent and semi-recumbent position, can muscle action be kept at a minimum and, correspondingly, the exactness of succeeding planigraphic levels maintained. This is essential both for diagnosis and for comparison of the same level from day to day or from week to week. It is a fact that planes no farther apart than 2 mm. show significant differences that can be verified day after day. If the patient supports himself at all, that is if he is not completely relaxed, as is impossible in the vertical position, reproduction of the same level must be much more difficult if not impossible, even with an intelligent patient."

Reproductions: For the past few years the Committee has considered mass reproductions of chest roentgenograms so that each member of our society could have *bona-fide* illustrations of the effect on pathological lesions in the lung of different techniques. We hoped this year to finish the project, but war interests interfered. We did decide, however, that the reproductions should be $8\frac{1}{2}''$ x $11''$ instead of $14''$ x $17''$, and that the first set should illustrate the effect of three different exposure techniques on a case of minimal tuberculosis of the lungs.

Recommendations: The Committee recommends: (*1*) that old projects be closed as soon as feasible and new fields be explored, always with the idea of being of practical help in chest roentgenography; (*2*) that funds be provided for two meetings in New York City during the coming year.

AMERICAN TRUDEAU SOCIETY

Report of the Committee on Tuberculosis in Industry

Dr. Leroy U. Gardner, *Chairman*

Dr. Leopold Brahdy
Dr. Lloyd Hamlin
Dr. H. E. Hilleboe
Dr. C. Howard Marcy
Dr. Oscar A. Sander
Mr. B. E. Kuechle
Dr. Wm. P. Shepard
Dr. C. D. Selby

The Committee on Industrial Tuberculosis, a joint committee of the National Tuberculosis Association and the American Trudeau Society, held its first meeting in Pittsburgh on November 12, 1943. Its first act was to petition the appointing bodies to change its name to the *Committee on Tuberculosis in Industry* in order to broaden the scope of its activities.

The Committee defined its objectives as follows:

1: To facilitate the use of organized agencies in combating tuberculosis in industrial groups.
2: To stimulate the interest of state and local tuberculosis associations and medical organizations now interested in tuberculosis in a field with which many such groups are still unfamiliar.
3: To disseminate accurate information on the industrial environments that do and those that do not affect resistance to tuberculosis.
4: To earn for organized tuberculosis agencies the confidence of industrial management and labor.
5: To coöperate with the medical profession and other interested agencies in making diagnostic services available to small plants.
6: To assist in developing standardized procedures for surveys, diagnosis, reporting and disposition of cases.
7: To assist in developing sound employment policies for persons with abnormal chest conditions.

Mr. William A. Doppler of the National office had been at work on a manuscript for a booklet to be entitled *A Guide to Industrial Relations for Tuberculosis Workers.* This manuscript had already been read and criticized by the members individually. The Committee advised further revisions and the elimination of sections dealing with the techniques of survey procedures. The revised booklet under the title *Tuberculosis: Labor and Management* was published by the National Association over Mr. Doppler's name in January, 1944.

The Committee assumed responsibility for the preparation of a second booklet dealing with Survey Procedures and Dr. Herman Hilleboe, with the assistance of Dr. David W. Gould of his Department in the Public Health Service, was requested to draft an outline for discussion and further consideration. Doctor Hilleboe reports progress and hopes to have a report within six months. In this project, the Committee is collaborating with a subcommittee of the Council on Industrial Health of the American Medical Association.

Communications from representatives of labor had indicated its dissatisfaction with the prevailing system of preplacement and periodic medical examinations, due largely to misunderstanding of the objectives. Discussion disclosed that not only labor leaders but often management and employees themselves failed to realize the purposes of such examinations. Doctor Sander is preparing a draft of rules governing the employment of persons with evidence of various manifestations of nonclinical tuberculous and other pulmonary conditions. He hopes to have this available for discussion by the Committee in the near future.

The Committee approves and strongly recommends general acceptance of the *Wisconsin Physical Examination Program*, a pamphlet representing mature consideration by labor, management and medicine in that state. Special attention is directed to the sections dealing with reports to employer and employees on the findings in industrial medical examinations.

The Committee has discussed the disposition of cases of tuberculosis disclosed by surveys and points out the need for coöperative effort by all local facilities. It recommends that family physicians be stimulated to participate in this endeavor by booklets of the nature of the most excellent one prepared by the Michigan Anti-Tuberculosis Association, which deals very briefly with the essentials of diagnosis, follow-up, hospitalization and reporting of cases. The assistance of the Committee on Education of the American Trudeau Society is solicited to this end.

It is recommended that local antituberculosis agencies exercise great caution in undertaking surveys of industrial groups exposed to dusts, fumes and gases and that this only be done upon the advice of special consultants, experienced with the particular hazards and after arrangements for expert interpretation of films

AMERICAN TRUDEAU SOCIETY

Report of the Medical Advisory Committee on Health Education

Dr. E. S. Mariette, *Chairman*

Dr. Charles P. Cake — Dr. Kirby S. Howlett, Jr.

Dr. H. McLeod Riggins

The Medical Advisory Committee on Health Education is charged with the responsibility of checking the medical facts in the various publications put out by the National office, but the way these facts are phrased is the responsibility of the staff.

With that understanding, the Committee has reviewed the following articles:

Early Diagnosis Campaign 1944 Progress Report
Get a Chest X-ray—Everybody's Doing It
1944 EDC—Leader Pamphlet. Let's Take His Picture
Huber the Tuber
EDC 1944—Cartoon Leaflet
EDC 1944—Pay Envelope Stuffer
Tuberculosis from 18 to 80
Home Care of Tuberculosis. The Family Physician in Charge
What You Should Know about Tuberculosis. The Patient's Questions Answered
Manual "Tuberculosis, Management and Labor"
EDC Slogan Suggestion from Michigan Tuberculosis Association
Help Fight Tuberculosis
Several pages of manuscript copy dealing with communicable diseases, including tuberculosis, which were to be part of the 1944 Christmas Seal School Program
Booklet of Biographical Sketches
Health for Victory (Talking Points)

Two members, Dr. Charles P. Cake and Dr. Kirby S. Howlett, Jr., have brought "new blood" into the Committee. Their replies have been received promptly, show good judgment and are very much to the point. They are a distinct addition to the Committee.

Since all the members of the Committee are now sending their reports to the Chariman, together with carbon copies which may be transmitted to the National office if that seems desirable, the Chariman is now able to send one complete report to the National office embodying the ideas of the members rather than having it receive several independent uncorrelated reports.

The Chairman again suggests that this Committee as a whole or a representative of it be authorized to attend the annual conference of the entire Advisory Committee on Health Education.

The Chairman has enjoyed working with the other members of the Committee whose approach to the work is broad-minded and free from personal bias. He wishes to thank them for the clarity of their reports and the promptness with which they have been made.

The Chairman hopes the National office will feel free to make whatever suggestions it feels will improve the work of the Committee.